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HU... BIOLOGY

a recor... of research

FEB...ARY, 1953

Vol. 25. 1

PUBLISHED ... QUARTERLY

THE JOHNS HOPKINS PRESS, BALTIMORE, MARYLAND, U.S.A.

HUMAN BIOLOGY

a record of research

FOUNDED BY RAYMOND PEARL

Editor

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in association with

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HUMAN BIOLOGY is published quarterly by The Johns Hopkins Press, Baltimore, Maryland, U. S. A. The advance subscription price is $5.00 a year (foreign postage 35 cents; Canadian 15 cents). Single current issues are $2.00 each; back numbers, $3.00 each; back volumes, $6.00; plus postage. Subscriptions for less than a year are charged at the single issue price.

Subscribers should notify the publishers of change in address at least two weeks before publication of the issue with which change is to take effect. No claim for non-receipt of an issue will be entertained unless made immediately upon receipt of the next succeeding issue.

Manuscripts and communications regarding editorial matters should be addressed to Editor, Human Biology, Department of Anatomy, 1512 St. Antoine St., Detroit 26, Michigan.

THE JOHNS HOPKINS PRESS, *Publishers*

BALTIMORE—18, MARYLAND, U. S. A.

Entered as Second Class matter, February 18, 1929, at the Post Office at Baltimore, Md., under the Act of March 3, 1879.

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FEBRUARY, 1953

VOL. 25 No. 1

A NEW BOARD OF EDITORS

With this issue *Human Biology* appears under a new board of editors, and we take this opportunity to introduce ourselves to our readers—although we realize that you will come to know us best through our work.

Five associate editors have been named. Dr. Josef Brožek of the Laboratory of Physiological Hygiene at the University of Minnesota is known for his studies of the composition of the human body. Dr. Bentley Glass of the Department of Biology at The Johns Hopkins University is interested in genetics and recently has been applying the theoretical concepts of population genetics to data on isolated human groups. Dr. Donald Mainland of the Department of Medical Statistics, New York University, is especially active in the application of bio-statistics to clinical and laboratory investigation in medicine and the study of age changes and of physiological norms. Dr. James N. Spuhler of the Institute of Human Biology at the University of Michigan is trained in anthropology, zoology and human genetics. Dr. Spuhler's research deals particularly with the interaction of social and biological factors in the dynamics of human racial groups. Dr. William L. Straus, Jr., of the Laboratory of Physical Anthropology of The Johns Hopkins University is particularly concerned with the biology of living primates and with human evolution. The editor himself teaches anatomy and is principally interested in anthropology.

As *Human Biology* acquires a new editorial board, we take the opportunity to inform the readers of our goals. Our aim is to represent more fully what our name implies, the intellectual meeting place for students of human biology. While preserving its high traditions, we should like to see this journal grow, more especially in the direction of that kind of human biology which is basic to preventive medicine, physical anthropology and social biology. To do so, we need only keep up with those investigators who are running out in front. It will be our aim to present their contributions to the fields of human genetics, development, growth, reproduction and aging, functional anatomy, bio-anthropology, human ecology and population dynamics.

While our field is *human* biology, we shall not confine our attention narrowly to human life; for to understand that life in all its aspects it is often helpful to observe other forms of life. Just as comparative and experimental studies of various animals have contributed to knowledge of human disease, they can also contribute to knowledge of normal processes in man. Therefore, while it remains our chief purpose to elucidate human biology, we shall, as opportunity affords, also present articles relevant to that purpose in which the subjects of investigation are drawn from other fields.

Lack of a formal society of American human biologists imposes on the editors of *Human Biology* the responsibility of representing all aspects of this vast field of biological science. It also imposes a duty of active participation on the readers. They can help by informing the editors about new projects of research or other matters of professional interest, and by suggesting subjects they would like to see taken up in *Human Biology*. Some have already done so. We wish especially to mention Dr. William W. Howells, the editor of the *American Journal of Physical Anthropology*, who has been very helpful in suggesting suitable articles for publication.

We start our task under auspicious circumstances. A generous grant from the Wenner-Gren Foundation for Anthropological Research will permit us to publish a full volume this year. We take this opportunity to express our gratitude to the Wenner-Gren Foundation. For the future, we place our faith in the continued support of our readers and hope that they will call the attention of their colleagues to the development of our journal.

GABRIEL LASKER
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Wayne University College of Medicine

SOME VITAL STATISTICS BASED ON SKELETAL MATERIAL[1]

BY MARCUS S. GOLDSTEIN

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I DO not remember whether I read *The Indians of Pecos Pueblo* voluntarily or under duress as required classroom work, but I did read Professor Hooton's massive contribution ('30), and I was deeply impressed with the sweep of his treatment of the material. Here, it seemed to me, the bones were made to represent living people; their age at death was not merely recorded, but was commented upon; the skeletons were not merely sexed, but sex ratios were considered in their biological-demographic context; and so on. Hence, when I had the privilege some years ago of working up Indian skeletal collections at the University of Texas, I made an attempt to follow the Pecos Pueblo lead, and to answer questions such as: How long did these individuals live? What factors influenced their average length of life? What were the male to female ratios and how might these have affected the survival of the groups? Some evidence pertaining to these questions and comments on their possible implications will be presented below.

The Texas skeletal material came from all the major regions of the state, although most of it was from south, central, and northeast Texas. The skeletons represented peoples living between 800-1700 A. D., according to the University archaeologists (Krieger, '46, and personal communications); most of the material, however, came from pre- or protohistoric horizons.

LENGTH OF LIFE

Estimation of age in the juvenile depended primarily on state of tooth eruption. In the adult, age was judged by degree of tooth wear,

[1] I am grateful to Dr. J. Lawrence Angel for a critical and generously helpful perusal of this paper.

epiphyseal union in the skeleton, extent of suture closure in the skull, and general condition of the bones, e. g., vertebral lipping as an indication of old age (Hrdlička, '39).

As noted in Table 1, the mean life span, based on age at death, was about 30 years among the Indians living in Texas,[2] compared with a

TABLE 1

Mean "life span" of Texas Indians and other groups, both sexes

GROUP	AGE IN YEARS	NUMBER OF INDIVIDUALS
Texas Indians (850-1700 A. D.)	30.5	767
Indians of Pecos Pueblo (800-1700 A. D.)[1]	42.9	587
Ancient Greeks (670 B. C.-600 A. D.)[2]	23.0	544
English (11th century)[3]	35.3	143
Europe, ruling families (1480-1579)[4]	33.7	..
U. S. White (1800)[5]	30–35	..
U. S. Negro (1900)[5]	33.8	..

[1] Calculated from Todd's estimates given by Hooton, '30, p. 19. If the tree-ring dating by Dr. A. E. Douglass, cited by Dr. Hooton, p. 342, is accepted, the time period would be 1100-1700.

[2] Unpublished data generously provided by Dr. J. Lawrence Angel, based on 307 adults, and "younger ages derived from fairly reliable cemetery statistics."

[3] Todd, '27, p. 491.

[4] Peller, '47, p. 82.

[5] Krogman, '40, p. 449; life expectancy from birth.

mean of about 43 years for the Pecos Pueblo Indians. It may be noted here that the Texas groups, except those in the northeast, were mainly non-agricultural, in contrast with the agricultural community at Pecos Pueblo. The mean life span of the American Whites at the beginning of the 19th century was apparently also quite short (Table 1). Indeed,

[2] Mean "life span" refers to the arithmetic mean of all ages at death. No allowance was made for loss of skeletons, especially infant material, through disintegration. According to Dr. J. Lawrence Angel (personal communication), in Macedonia at Olynthus only 22% of infant graves had skeletons compared with 80-90% of adult graves having some bone fragments. Assuming that in Texas some 25% of the infant graves (0-4 years) had been recovered, and equating this percentage with an estimated 80% recovery for the remaining ages, some 307 infant skeletons or 31 percent of the total should have been recovered, and the average age at death, all ages, would be reduced to about 24 years. It is of interest in this connection that 30% of all deaths among the Mohave and

the mean age at death of the various groups cited manifests a similarity, with the exception of the Pecos people, which seems to me to suggest that race was not much, if at all, involved in the average number of years lived.

Table 2 gives some idea of the mortality at various age periods in the Texas and other groups. The relatively small representation in the 0–4 years interval in the Texas series is undoubtedly due to the greater likelihood of loss or disintegration of the fragile infant skeleton in

TABLE 2

Mortality at various age intervals: Texas Indians and other groups[1]

GROUP	ALL AGES	AGE AT DEATH (YEARS)					
		x–3	4–9	10–19	20–34	35–54	55+
	PERCENTAGE DISTRIBUTION						
Early Indian groups in Texas	100.0	12.5[2]	4.7[3]	10.4	29.2	29.6	13.6
Indians of Pecos Pueblo.....	100.0	14.4	7.7	7.7	12.5	39.7	18.4
U. S. Registration Area, 1910	100.0	15.0	2.6	2.4	7.0	15.6	57.5
Italy, males, 1901-1910.....	100.0	25.0	3.7	2.8	6.6	12.1	49.8
U. S., Negro males, 1910....	100.0	32.1	4.6	5.1	11.3	17.9	29.1
India, males, 1901-1910.....	100.0	39.7	10.1	6.4	12.3	16.8	14.8

[1] All data other than the Texas Indian are from Hooton, '30, p. 25.
[2] Refers to ages 0–4 years.
[3] Refers to ages 5–9 years.

the course of time. Too, an unusually large percentage of Texas skeletons falls in the age period 20–34 years. Whether this concentration is due to bias in the estimation of age, or a chance recovery of a disproportionate number of young adult skeletons, or reflects a demographic reality, I do not know. The Texas Indian material is catalogued and stored at the University of Texas and no doubt could be checked for age and other observations. Indeed, the variation among workers in estimating age and sex could, and should, be tested on series of skeletons, preferably of known sex and age at death. These "tests" might be held periodically during meetings of the American Association of Physical Anthropologists.

Chemehuevi Indians of western Arizona between 1910-1930 were in the age group 0–4 years; the calculated mean age at death was 32 years (Clements, '31, p. 398).

To return to Table 2, it may be noted that relatively few individuals apparently lived beyond middle age in either the early Indian groups of Texas or at the Pecos Pueblo (14% and 18%, respectively). Interestingly, just about the same proportion of people reached old age in England in the middle ages, or for that matter, in recent times in India.

Sex. Unlike the present longer life span of the female, the males apparently lived longer on the average than the females among the early Texas Indian groups and ancient Greeks (Table 3). The rela-

TABLE 3

Age at death, by sex: Texas Indians and Ancient Greeks [1]

GROUP	NUMBER OF INDIVIDUALS	MEAN AGE (YEARS)	PERCENTAGE DISTRIBUTION AT AGES			
			18–19	20–34	35–54	55+
Texas Indians						
Males	270	41.0	2.6	25.2	45.9	26.3
Females	237	33.9	5.5	48.1	35.0	11.4
Ancient Greeks [2]						
Males	249	39.8	0.8	39.4	54.6	5.2
Females	135	31.0	14.1	63.0	22.2	0.7

[1] All ages under 18 years are excluded in order to attain greater reliability of the sex determinations.

[2] Angel, '47, p. 20.

tively much larger number of female skeletons than males adjudged 18–34 years of age at death very likely reflects the high maternal death rate at childbirth which must have prevailed at the time.

Locality. Was there any difference in mean life span among the various Texas Indian groups represented by skeletal remains? To answer this question, the material was divided by regions roughly approximating archaeological divisions in the State.[3] Table 4 gives the results.

[3] Northeast Texas or "Caddo Area" includes the Sanders Focus and Texarkana Focus; North Texas, the Henrietta Focus and Antelope Creek Focus (Texas Panhandle); Central Texas, the Edwards Plateau Culture; West, in the present instance, refers almost altogether to remains of cave-dwellers (see Krieger, '46).

Fairly good series of skeletons were available from three sites, and age at death of the people at these places is shown in Table 5. The Sanders site in northeast Texas refers to a period circa 1300-1400 and

TABLE 4

Mean age at death of Texas Indians, by location

LOCALITY	BOTH SEXES [1]		MALES [2]		FEMALES [2]	
	Number	Age	Number	Age	Number	Age
North (1250-1450)	63	34.8	33	41.1	20	32.7
South (——1700)	285	30.5	89	41.4	103	31.2
Northeast (1300-1600)	227	30.3	70	40.6	76	33.4
Central (850-1450)	144	29.6	56	41.1	30	44.9
West (900-1300)	48	28.5	22	40.9	8	34.2
Total	767	30.5	270	41.0	237	33.9
S. D.		18.5				

[1] The number of cases in both sexes as compared with the combined number of males and females differs by the number of cases under 18 years of age, sex of which in most cases could not be determined with reasonable certainty.

[2] Includes cases 18 years of age and over only.

TABLE 5

Mean age at death of Indians at three localities in Texas as estimated from their remains, both sexes

GROUP	ALL AGES		ADULTS ONLY				
					Percentage at ages		
	Number	Mean age	Number	Mean age	18–34	35–54	55+
Sanders site (northeast Texas) ..	69	37	51	42	27.5	43.1	29.4
Morhiss mound (south Texas)	98	31	58	36	44.8	34.5	20.7
Oso site (south Texas) ..	68	27	46	34	60.9	21.7	17.4

revealed the practice of agriculture and a relatively advanced culture (Krieger, '46). The Oso and Morhiss sites in south Texas were pre-Columbian and showed no sign of the practice of agriculture. Rather

substantial differences are noted between the mean age at death among these several groups, especially between the Sanders and Oso peoples.[4]

European Contact. The material has been further divided according to archaeological manifestation of European contact. European contact in the present instance almost altogether means merely association with European artifacts. Direct and extensive white contact among the groups represented by their skeletal remains occurred perhaps only in the case of the mission Indians of south Texas, whose remains comprise a very small proportion of the total examined. In any case, the mean age at death of 55 individuals from sites showing European contact was 40 years, and of 290 individuals manifesting no such association, 36 years.[5] The difference between the means is not statistically significant at the 5% level of probability.

Agriculture and Length of Life. A test was made of the hypothesis that the practice of agriculture by a group—presumably indicative of a more sedentary existence and stable economy than among groups not practicing agriculture—was conducive to longer life than in primarily hunting or fishing cultures. The mean age of all the material from sites showing definite signs of the use of agriculture (104 individuals) was 39 years; that of the non-agricultural group (241 individuals) was 35 years. Unexpectedly, the difference between the means in this instance is not significant at the 5% level of probability.

SEX RATIOS

A few comments may be made on the ratios of males per 100 females as found in the Texas remains and in other groups. Although the Texas Indian data on sex given in Table 6 are not strictly comparable with Professor Hooton's Pecos Pueblo figures or those from the U. S. Census, since sex was estimated beginning at 10 years of age in the Pecos material and was recorded at all ages in the Census, it is of

[4] Ages at death for all the skeletons observed at these sites were not available to me when this paper was written, and hence the statistical significance of the differences between the means could not be calculated. However, the chi-square may be computed from the distributions given for the adults; only the Sanders compared with the Oso data showed a chi-square that was significant at the 5% level of probability.

[5] The age data relating to European contact are based on skulls only, and hence the smaller number of total individuals than in the previous counts.

interest that the Texas Indian ratio of 112.6 is quite similar to both the Tanoan and Mexican male to female ratios. The total living Indian population in the United States in 1930 also manifested a higher ratio of males to females, but only slightly more so than in the United States whites at this time.

Age apparently has a considerable influence on the sex ratios. In

TABLE 6

Ratio of males per 100 females in Texas Indians and in other groups[1]

GROUP	MALES TO 100 FEMALES BY AGE				
	Total		18–34* Under 20**	35–54* 20–50**	55+* 51+**
	No.	Ratio	Ratio	Ratio	Ratio
Skeletons					
Texas Indian[2]	536	112.6	57.2*	141.3*	272.4*
Pecos Pueblo	667	140.8	70.9**	150.8**	146.2**
Living					
Jemez Indians (1910)	499	128.9	104.7**	152.8**	142.3**
All Tanoan Indians (1910)	3,137	108.7	92.4**	120.6**	136.2**
U. S. Indian (1930)	..	105.1	..	..	..
U. S. Mexican (1930)	..	114.3	..	..	..
U. S. White (1930)	..	102.7	..	..	..
U. S. Negro (1930)	..	97.0	..	..	..

[1] The Pecos, Jemez, and Tanoan groups are from Hooton, '30, p. 31; the 1930 data are from the 15th Census of the United States, Summary, p. 8.

[2] Includes 29 cases from Stewart, '35, p. 215.

the Texas material and also in the Pecos remains, as well as for the cited living Indians groups, females definitely outnumbered the males in the early years, but in turn were outnumbered in the middle years and especially in old age, one more indication of longer life among the males.

A pertinent passage of Professor Hooton's on the sex ratio may well be given in full ('30, p. 31):

"I have been inclined to attribute the great excess of males in skeletal population to the better weathering of male skeletons or to a possible tendency of the laboratory worker to assign to the male sex skeletons of masculine appearance which were in reality females. How-

ever, the comparison of the Pecos skeletal population with the sex ratios in living peoples of the same stock indicates that the great excess of males should not be attributed to any such source of error.

"In a population which is remaining stationary or declining in numbers one expects the number of males to exceed markedly the number of females. This excess of males is usually attributable to an actual difference of the proportions of the sexes at birth. We need not here discuss the hypothesis of the relation of nutritional factors to sex determination, but it may be remarked that if, as some think, a well nourished and increasing population produces an excess of females at birth, whereas a badly nourished and declining population produces an excess of males at birth, we may well expect the population of the extinct Pecos pueblo to manifest in a high degree the latter type of disproportion of the sexes."

That a badly nourished people necessarily is a declining population would seem rather dubious in view of the examples of China and India, countries in which malnutrition is notoriously common and yet, so far as I am aware, they suffer from no lack of fecundity. The other point raised, that an excessive proportion of males over females is indicative of a stationary or declining population, seems to me provocative and should be explored further. What conditions induce such a disproportion in the sexes in present populations? What might they have been among early Indian groups?

In my closing remarks I would like to suggest that length of life was and is affected as much or more by the culture of a group and its neighbors as by the biological or genetic constitution of its members. Variations in the potential life span of individuals very likely do occur. Yet, as suggested by the Pecos Pueblo material, a cultural artifact, agriculture, or the more secure mode of living implied by an economy dependent on or considerably supplemented by agriculture, apparently had a significant influence on length of life, and probably also on the chance of initial survival. The risk of accidental deaths must have been much greater among nomadic than among sedentary groups.

A striking example is given by Kroeber ('39, p. 148) of the effects of a social custom on the very existence of the eastern American Indians. Thus, their "warlike habits [were] so integrated into the whole fabric of Eastern culture, so dominantly emphasized within it, that escape from it was well-nigh impossible. This warfare, with its attendant unsettlement, confusion, destruction, and famines, was probably the most potent reason why population remained low in the East."

The late Professor Wingate Todd, also commenting on the subject, stated ('27, p. 496):

"The difference between the peaks of mortality in primitive and ancient people on the one hand and of modern civilized humanity on the other is roughly thirty years. This difference does not indicate a prolongation of the potential duration of life which undoubtedly remains stationary through the ages. In modern populations, even in civilized communities, drawn from the lower strata of society, the old age peak characteristic of today is not to be found, owing to the relatively great hazards of life to which these unfortunate people are exposed when not sheltered by specific social legislation."

Some have suggested on the basis of life expectancy curves from epigraphic data and skeletal remains, and an assumed "rigorous selection at earlier ages," that persons in ancient times may have had a longer life expectancy after reaching old age (i. e., life expectancy at age 65 or thereabout) than is the case at present even in a country like England or the United States (Pearson, '01; Macdonell, '13; Angel, '47). Be this as it may, it should be clear that large numbers of people living to old age (65 years and over), as distinct from continued life span of individuals in the old-age brackets, is a very recent phenomenon, probably limited to countries and groups in which the infant and child mortality rates are low and modern public health and medical care services are generally available.[6]

SUMMARY

Mean age at death of Indians living within the present bounds of Texas, for the most part in pre- and protohistoric times, is estimated as about 30.5 years on the basis of examination of 767 of their skeletons. When account is taken of a high rate of nonrecovery of infant skeletons, the average age at death is reduced to about 24 years. Mortality at different age periods is noted; a large percentage of deaths apparently occurred in the age period 20–34 years. Relatively few individuals (14%) lived beyond middle age. Males seemingly lived longer than females. Variation in mean age at death among groups located in

[6] In the United States, for example, the infant mortality rate (deaths under 1 year per 1,000 live births, for birth registration States) decreased from 85.8 in 1920 to 31.3 in 1949; and according to the censuses, the percentage of the population aged 65 and over was 2.9 in 1870; 4.1 in 1900; 4.7 in 1920; and 8.2 in 1950.

different parts of the State is indicated. Considering adult skeletons only (18 years and over) the male to female ratio was 112.6. The implication of cultural factors on length of life is discussed.

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BIRTH INTERVAL AND BODY SIZE

BY W. W. HOWELLS

University of Wisconsin [1]

IN connection with a study of body size and birth order, the writer (1) examined certain other family characteristics in relation to body size, one of them being birth interval. There were found preliminary indications that those whose births had followed relatively soon after that of the next oldest sibling were shorter on the average in adult stature. Such a possibility would not be unreasonable, on the hypothesis that a new pregnancy in the immediate post-partum period might find that mother's reproductive system not fully restored to "normal." Yerushalmy (4) found evidence that stillbirth rates were higher for the shortest (and also the longest) birth intervals, and cited previous work which had, by methods different from his, demonstrated the same effect.

Whether this influence might also have an effect on post-natal development is another matter. Such a factor, if actual, might be a significant non-genetic cause of familial variation: it might, for example, explain the slight, and statistically unreliable, tendency found by the writer, in the study cited above, for older brothers to exceed younger brothers in stature, particularly, by the argument that elder brothers would include a proportion of first births (as younger brothers would not) who thus could not have been exposed to the hazard suggested: a less favorable pre-natal environment due to the demands made upon the reproductive tract by a very recent occupant of it.

At any rate suggestions were found, as has been said, in the brother material of smaller stature for short birth intervals. However, the material was then in improper form for study of the question, and an

[1] This study was supported by the Research Committee of the Graduate School, from special funds voted by the Wisconsin State Legislature. Measuring or computation involved was performed at various times by Earle L. Reynolds, T. W. McKern, R. L. Hornseth, N. C. Tappen and R. F. Maher.

analysis was tried on another series, of Short Course students, entirely of Wisconsin farm extraction, measured in 1942. In this case, analysis of variance showed that the distribution of stature by "interval to previous birth" was abnormal, the abnormality (excess of between-group variance) being significant at the 1% level; also, those with the shortest interval to previous birth (1 year) were significantly shorter in stature

TABLE 1

Relation of stature and birth interval. Moving averages, 4-month groupings

INTERVAL TO PREVIOUS BIRTH IN MONTHS	STATURE MEANS	
	UNIVERSITY STUDENTS, 1947	SHORT COURSE STUDENTS, 1947
10	168. (1)	187. (1)
10–11	168. (1)	187. (1)
10–12	173.00 (3)	187. (1)
10–13	174.40 (5)	173.62 (8)
11–14	172.00 (12)	170.73 (11)
12–15	173.47 (15)	170.73 (11)
13–16	173.21 (19)	171.70 (17)
14–17	173.04 (22)	171.54 (11)
15–18	175.33 (18)	174.09 (11)
16–19	175.00 (18)	174.67 (12)
17–20	176.48 (23)	175.62 (13)
18–21	177.52 (21)	176.50 (14)
19–22	177.30 (23)	176.91 (11)
20–23	177.30 (20)	174.31 (13)
21–24	177.00 (10)	173.00 (6)
22–25	175.75 (8)	171.67 (6)
23–26	176.43 (7)	168.43 (7)
24–27	176.08 (12)	171.40 (5)
25–28	176.94 (16)	172.83 (6)
26–29	176.70 (17)	173.43 (7)
27–30	176.30 (13)	177.00 (9)

than the total group. Here also, however, the groupings were unsuitably coarse (birth interval being reckoned in round years, from the ages of the subjects), and consequently the results are not reproduced. Nevertheless this indicated further work along the same lines with birth interval reckoned more precisely, i. e. in months. This impression was sustained by later preliminary runoffs of results, shown in Table 1;

these, based on the small numbers of subjects available, indicated that a division at 18 months would be a reasonable one for the analysis of the rest of the material, and that, because of the small numbers, groupings had best consist of: first-born, interval x-18 months, and interval 19-x months, without further subdivision.

Means according to these groupings for all measurements were run off for four separate series, three of them being Short Course student groups measured in different years (composed entirely of Wisconsin farm-living young men) and one being a series of University students from urban, non-farm homes.[2] The results were negative; i. e. there was no general, reliable indication of differences in body form as between those characterized by short intervals to previous births, and those characterized by longer intervals, or first-born. It is believed that the results should be reported anyway, for the benefit of those interested in problems of possible non-genetic effects on physique.

These results are given in Table 2. In view of the lack of positive

TABLE 2

Short Course Students, 1942

	FIRST BORN	INTERVAL TO PREVIOUS BIRTH	
		x-18 MOS.	19-x MOS.
NUMBER	31	11	42
Stature	176.00	174.27	175.00
Sitting height	92.06	91.64	91.40
Total arm length	78.06	77.73	77.57
Length of radius	268.16	261.18	264.14
Length of tibia	396.58	395.00	394.17
Biacromial	398.48	397.36	395.52
Biiliac	307.68	300.55	302.60
Head circumference	568.42	558.09	566.40
Head length	196.81	192.73	195.48
Head breadth	153.52	150.82	152.43
Minimum frontal	105.65	104.64	104.57
Bizygomatic	137.94	139.27	136.86
Bigonial	108.00	109.73	106.14
Face height	132.10	128.36	130.71
Upper face height	82.00	80.64	80.51
Nose height	63.16	61.55	62.49
Nose breadth	35.32	36.64	36.24

[2] This material was originally obtained by T. W. McKern (3), to whom I am obliged for permission to use it for the present purpose.

TABLE 2 (Continued)

Short Course Students, 1947

	FIRST BORN	INTERVAL TO PREVIOUS BIRTH	
		x-18 MOS.	19-x MOS.
NUMBER	15	17	40
Stature	171.20	174.00	175.92
Sitting height	88.87	90.71	91.50
Total arm length	78.27	80.47	79.73
Length of radius	261.73	257.29	262.68
Length of tibia	374.27	386.47	390.20
Biacromial	396.47	395.71	394.10
Biiliac	287.87	299.18	300.48
Head circumference	561.33	567.06	567.03
Head length	191.47	191.47	193.93
Head breadth	152.00	153.12	153.48
Minimum frontal	103.33	102.59	104.20
Bizygomatic	137.60	138.35	138.90
Bigonial	108.53	108.00	109.38
Face height	127.73	124.65	129.18
Upper face height	78.67	75.29	77.45
Nose height	58.73	57.06	58.78
Nose breadth	35.13	34.29	35.75

TABLE 2 (Continued)

Short Course Students, 1948

	FIRST BORN	INTERVAL TO PREVIOUS BIRTH	
		x-18 MOS.	19-x MOS.
NUMBER	27	14	66
Stature	175.19	171.21	173.59
Sitting height	92.00	89.14	91.08
Total arm length	78.52	76.93	78.06
Length of radius	262.74	266.07	258.95
Length of tibia	394.96	390.36	389.74
Biacromial	409.22	416.36	408.92
Biiliac	292.37	289.29	291.30
Head circumference	567.89	564.14	564.74
Head length	193.30	192.14	193.20
Head breadth	153.26	153.43	152.77
Minimum frontal	103.00	101.57	102.21
Bizygomatic	138.59	138.36	138.32
Bigonial	105.07	104.57	104.91
Face height	126.70	127.57	125.35
Upper face height	76.37	78.21	75.30
Nose height	58.26	59.57	57.62
Nose breadth	35.07	34.67	35.26

TABLE 2 (Continued)

University Students, 1947

	FIRST BORN	INTERVAL TO PREVIOUS BIRTH	
		x-18 MOS.	19-x MOS.
NUMBER	85	31	99
Stature	175.95	173.81	176.46
Sitting height	91.32	90.58	91.56
Total arm length	77.31	77.80	78.29
Length of radius	256.11	254.55	253.72
Length of tibia	394.06	392.19	394.40
Biacromial	409.50	409.71	407.03
Head circumference	569.05	568.61	569.43
Head length	194.09	195.19	194.39
Head breadth	153.60	153.39	154.23
Minimum frontal	105.65	105.13	106.11
Bizygomatic	139.09	139.58	138.55
Bigonal	106.53	107.07	106.42
Face height	130.47	129.10	130.19
Upper face height	78.96	77.90	79.09
Nose height	61.24	59.65	61.47
Nose breadth	38.45	38.87	38.29

trends it is clearly unnecessary to carry out extensive tests of significance of differences, and only the means are given. A larger single series might have been obtained by combining the three Short Course series, whose background is essentially identical except for year of attendance; however, analysis of variance in several measurements showed that this could not be properly done; the groups cannot be accepted as samplings from the same universe, in this case obviously because of differences in measuring technique, the three series having been measured by two different observers.

Stature was the measurement of which the behavior in preliminary work led to the full investigation, and it is stature alone which shows a good degree of consistency throughout in favor of longer birth intervals. The only other measurements even suggesting such a trend are sitting height (certainly not limb lengths), head circumference, and possibly heights of the face. Perhaps shoulder breadth is consistent in an opposite trend, along with head breadth or minimum frontal. However, the suspicion is that all the variation is meaningless. Even in the greatest stature difference, in the University 1947 series, the long-interval group

exceeds the short-interval group by an amount significant only at the 5% level according to the t test; however, analysis of variance indicates that the whole distribution of stature in this series is probably not abnormal, indicating that this difference should be disregarded.

In Table 3 a further comparison is made, this one consisting of

TABLE 3

Mean differences, in millimeters, between contiguous pairs of brothers, all birth orders, according to interval between their births. (Plus values favor elder brothers).

	INTERVAL BETWEEN BIRTHS	
	x-18 MOS.	19-x MOS.
Stature	19.40 (25)	1.20 (49)
Sitting height	6.31 (26)	3.86 (50)
Upper arm length	— .42 (26)	2.70 (50)
Lower arm length	2.15 (26)	.75 (51)
Lower leg length	— .96 (25)	— 2.22 (49)
Biacromial	.96 (26)	2.76 (51)
Biiliac	.42 (26)	2.49 (51)
Head circumference	5.69 (26)	— 1.68 (50)
Head length	2.19 (26)	— .21 (51)
Head breadth	1.04 (26)	— .12 (51)
Head height	— .23 (26)	— 1.29 (51)
Minimum frontal	.77 (26)	— .98 (51)
Bizygomatic	1.38 (26)	1.08 (51)
Bigonial	.38 (26)	1.37 (51)
Face height	— .23 (26)	.61 (51)
Upper face height	— .62 (26)	.39 (51)
Nose height	.31 (26)	— .14 (51)
Nose breadth	— .54 (26)	.24 (50)
Ear length	.27 (26)	1.18 (51)
Ear breadth	— .58 (26)	— .51 (51)

actual differences between pairs of brothers (from Howells, 1, 2) according to birth interval. This has a complicating factor, since the older brothers are partly first births, and partly those who may have had a short interval to previous birth themselves. There is no indication of general trend, or of significant differences, in this material; however, stature follows the same trend, and biacromial breadth likewise follows the opposite trend. Nevertheless, the whole investigation cannot be accepted as demonstrating that interval to previous birth has an effect on physical development of the adult.

While this material was in preparation, and before the results were known, it was decided to look into another possible biological result of variation in birth interval: whether post-natal mortality, like the still-birth rate, might be influenced by this pre-natal factor. To get a population not under the influence of birth control (in its present overt form), and in which death had overtaken everyone, material was taken from the published Vital Records of Massachusetts towns, which list recorded births, marriages and deaths up to 1850 (and are apparently fairly complete in their listings of infant and juvenile deaths). The manner of searching this material—having to find both birth and death

TABLE 4

Birth interval and length of life. Data from Vital Records of Massachusetts towns; deaths prior to 1850.
(Expected frequencies in italics).

INTERVAL TO PREVIOUS BIRTH	AGE AT DEATH			TOTAL
	0–20	20–50	50–x	
First born	10	11	7	28
	10.76	*9.49*	*7.75*	
0–20 mos.	15	21	12	48
	18.44	*16.27*	*13.29*	
21–30 mos.	25	19	23	67
	25.74	*22.71*	*18.54*	
31–x mos.	18	9	7	34
	13.06	*11.53*	*9.41*	
Total	68	60	49	177

$\chi^2 = 7.24$
degrees of freedom = 6
$P = .30$

dates of an individual—imposes at least two biases, neither of them unfavorable: the individuals concerned lived in the same town or nearby throughout life; and large families were necessarily selected, to give a better chance of finding both birth interval and death date for the same individual. First births are derived from the same families. Naturally, even with plentiful records, it is not too easy to make up a large sample of data; the 177 used were found without too great an expenditure of time, however, and were considered adequate for purposes of a test.

The result is shown in Table 4. This constitutes the most favorable

arrangement of the data for the hypothesis under scrutiny. It is evident that no support for the hypothesis appears. Even though the numbers are small, there is no encouragement to try a broader survey of the same kind.

The tests described in this paper are not only based on small numbers but are relatively crude, since other possible influencing factors, such as family size, age of mother, etc., cannot be isolated or held constant without more material.[3] The hypothesis, however, would appear to be discredited. Possibly the influence reported by Yerushalmy and others may have a selective effect, by tending to eliminate through stillbirth those suffering the handicap of a short interval to previous birth, or at least in this way reducing the residual effect of such a factor to a minimum. It would take a considerably wider study than the present one to discover if this is so.

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[3] Several such factors were investigated individually by using part of the material; none of them was found to have a discernible gross effect on stature. These factors were age of subject, age of mother at subject's birth, family size, and birth order. See also Howells (1).

THE DETERMINATION OF THE SEX OF SKELETONS, AS ILLUSTRATED BY A STUDY OF THE ESKIMO PELVIS

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THE purpose of this paper is to present a method of determining the sex of skeletons, which avoids the necessity of the investigator making subjective judgments. Not only are such determinations important in medico-legal cases but they are the first step in the study of archeological remains. In spite of the importance of this problem, there appears to be no objective method of ascertaining the sex, even of the pelvis. It has been standard procedure on the part of anthropologists in this country to sort skeletons of unknown sex into males and females and then to treat these groups separately. Clearly the sexual differentiation described in this way is dependent to an unknown extent on the biases of the person making the original decisions. If there were very few cases of doubtful sex, this might not be a matter of practical concern, but Howells ('41) estimates that there may be disagreement among experts in 15% of cases, and this is more than enough to cause major difficulty in the study of race, sex, and variability of prehistoric populations.

Studies on pelves of known sex from anatomical laboratories have shown that the pubic bone is relatively longer in the female and that the sex of the majority of pelves can be determined by the relative length of the ischium and the pubis (Washburn, '48, '49). However, these studies also show that there are racial differences in this index, just as there are in all other skeletal indicators of sex. Because of this variation it is not possible to apply the standards of samples of known sex to new series from widely varying times and places. Krukierek ('51) has shown that the form of the pelvis is affected by environment

(probably diet) and so standards must be applied with caution, even within the same racial group.

What is needed is a quantitative method which will divide a series automatically into those probably male and those probably female and which will allow some estimate of the error. To be useful the method must work, even if the degree of sexual differentiation in the new sample is somewhat different from that of any group previously investigated. It may be assumed that the sexual differentiation in the new series will be of the same general nature as that in samples of known sex, but the means and variabilities may well be different.

Since previous studies have described differences between American Whites and Negroes (Straus, '27 and Washburn, '48) and Bantu (Washburn, '49), Mongoloids were selected for this investigation. Through the generosity of Dr. T. D. Stewart it was possible for Hanna to study the extensive collection of Eskimo skeletons in the U. S. National Museum. We are grateful to Dr. Stewart for his help and advice. We wish to thank the Wenner-Gren Foundation for Anthropological Research whose financial support made this study possibles.

Material and methods. The series investigated consists of 224 skeletons of Eskimos from Alaska. No known Indians or Aleuts are included. The length of pubis, ischium, upper ilium, and lower ilium, and angle of the sciatic notch were measured on 224 right innominate bones. All were adult, judging by the pubic symphysis. Length of pubis and ischium were measured according to the technique described by Schultz ('30). In measuring the iliac heights the technique described by Straus ('27) was followed. The angle of the sciatic notch was determined by: placing the innominate bone, medial surface upward, on a piece of paper; tracing the shadow of the notch cast by a single, distant light; and drawing straight lines tangent to the sides of the notch. The angle between the lines was measured, and both the tracing and measurement were checked against the innominate bone to make sure that there had been no distortion. All the measurements were taken by Hanna.

Various methods of sorting the data were tried and the most effective is shown in Figure 1. If the ischium-pubis index is plotted on one axis and the angle of the sciatic notch on the other, the data are sorted into two distributions which are almost completely separate. After considering, in addition, the interiliac index and gross size, the two groups were divided, as shown by the line in Figure 1. Using this division, the mean, range and standard deviation of each measurement and index

was calculated, and the result are shown in Table 1. The correlations of the measurements and indices are shown in Table 2.

TABLE 1

Measurements and Indices of 95 "female" and 129 "male" Eskimo

	"FEMALE"				"MALE"			
	Mean	Range	S. D.	C. V.	Mean	Range	S. D.	C. V.
Pubis length, mm.	80.1	(73-90)	5.1	6.3	74.1	(63-85)	4.0	5.3
Ischium length, mm.	81.0	(72-89)	5.0	6.1	88.4	(79-98)	4.0	4.5
Ischium-Pubis Index, %	98.8	(91-109)	3.8	3.8	83.9	(73-92)	3.7	4.4
Sciatic Notch Angle, degrees	74.4	(61-93)	7.1	9.5	50.4	(26-65)	8.4	16.6
Upper Iliac Height, mm.	64.2	(50-76)	5.4	8.4	72.4	(61-85)	5.2	7.2
Lower Iliac Height, mm.	61.8	(54-77)	6.9	11.1	54.5	(42-67)	5.4	9.9
Interiliac Index, %	104.5	(73-140)	14.1	13.4	133.6	(100-177)	15.9	11.9

TABLE 2

Coefficients of Correlation

	"MALE"	"FEMALE"
Ischium-pubis Index and Angle of Sciatic Notch	+ .32	— .10
Ischium-pubis Index and Interiliac Index	— .08	+ .01
Pubis length and Lower Iliac height	— .06	+ .17
Ischium length and Upper Iliac height	+ .40	+ .37

Discussion. On the basis of the combination of the ischium-pubis index, the angle of the sciatic notch, the interiliac index, and gross size, the Eskimo innominate bones were divided into two groups, as shown in Figures 1 and 2. One group is characterized by high ischium-pubis indices, wide sciatic notches, low interiliac indices, and small size.

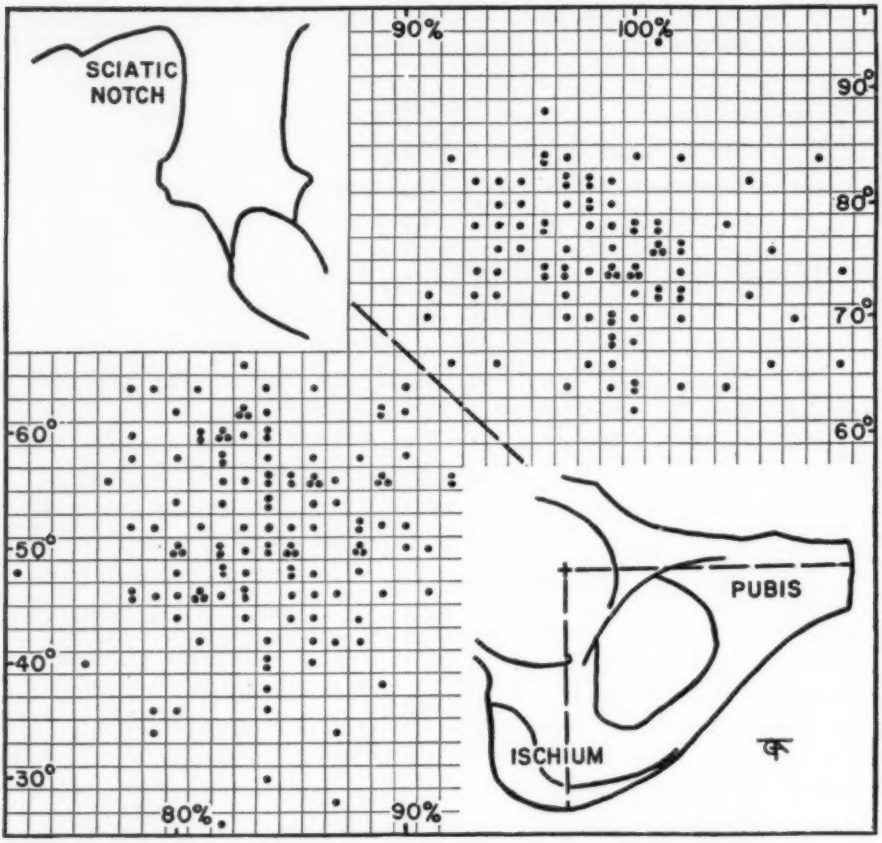

FIG. 1. THE ANGLE OF THE SCIATIC NOTCH IN DEGREES PLOTTED AGAINST THE ISCHIUM-PUBIS INDEX IN PER CENT. DIAGONAL LINE SEPARATES "MALES" AND "FEMALES."

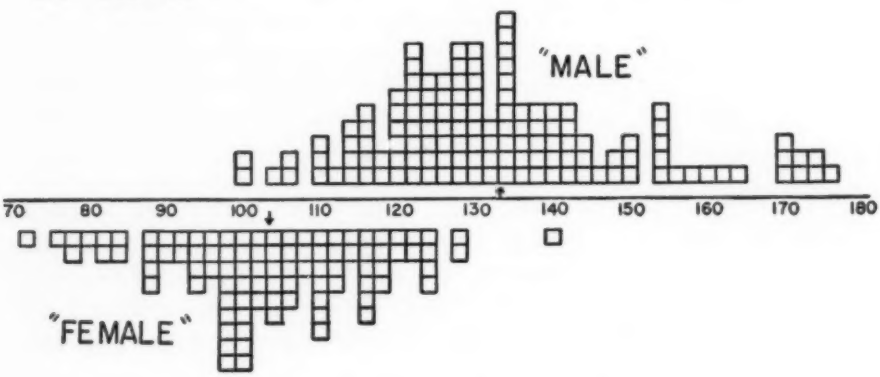

FIG. 2. DISTRIBUTION OF INTERILIAC INDEX.

Investigations of pelves of known sex have shown that these are the characteristics of females (Straus, '27 and Washburn, '48, '49). Conversely, the traits of the other group are those of males. The ischium-pubis indices of these Eskimo are almost identical with those of Whites of known sex from anatomical laboratories (White male, 83.6%, Eskimo, 83.9%; White female, 99.5%, Eskimo, 98.8%). There are very few cases which are intermediate in character, and, even the sorting shown in Figure 1, which is based only on the ischium-pubis index and the sciatic notch, separates over 95% of the total series into two very distinct groups. There is no indication of 15% of skeletons of uncertain sex, as has been suggested in the literature (Howells, '41, Hooton, '46).

Although most of the determinations of sex seem to be correct, there are some marginal cases, and these need to be considered in more detail to judge the effectiveness of the method. In considering the probability of the assignment of sex in any individual case, the consistency of the traits should be emphasized. There are no cases at all in which extreme male features are combined with female characters. For example, in the whole series there are many specimens with narrow sciatic notches and many with high ischium-pubis indices, but in no single case is an angle of over 70 degrees combined with an index of less than 90%. Conversely, a notch of less than 60 degrees is never combined with an index of over 92%. An interiliac index of over 140% never is associated with a wide notch or high ischium-pubis index, while interiliac indices of less than 100% only occur in combination with wide notches and high ischium-pubis indices. In other word, there are *no cases* in which a trait which is clearly male or female is combined with a character of the opposite sex. This method of sorting stresses the certainty at the extremes, rather than the probability computed from the averages. On the basis of series of known sex, and the combinations of traits in this series, there is no reason to suppose that extremely male traits ever occur in combination with extremely female traits, (barring pathology or very rare anomalies). Innominate bones whose sex can not be determined with certainty will be ones which are intermediate in all the characters used in sorting. In this series the borderline cases will have ischium-pubis indices between 90-92%, combined with angles of 60-70° and interiliac indices of 100-140%, with ischia 80-90 mm. long. There are only 2 such individuals in 224 cases.

Since there are very few errors in the assignment of sex, the means and standard deviation of the measurements and indices of each sex

will be approximately correct. Therefore, a calculation of the chances of error in the determination of the sex of an individual specimen can be made. The correlations between the characters used in sorting are low (Table 2), and, therefore, probability of error will be the product of the chances of each sorting criterion taken separately. The chances of successful assignment of sex are better than 10-1 for the ischium pubis-index, 5-1 for the angle of the sciatic notch, and 2-1 for the interiliac index. Theoretically the number of uncertain cases should be 1%, and there are two possibly intermediate cases in the series of 224 Eskimo pelves.

An independent check on the reliability of this method is possible because Hrdlička had marked his opinion of the sex on 173 skulls of these same skeletons. Our determinations agree with his in all but 8 cases. In 7 of the cases, in which we disagree the pelvis is clearly male or female, and we see no reason to change our opinion. In one of the 2 cases which are doubtful according to our criteria we disagree with Hrdlička, but here he disagrees with himself for he had marked the femur of this individual male and the skull female. Considering all the evidence, we feel that this is the only individual in the series whose sex is in reasonable doubt.

The method of determining the sex of innominate bones described here differs fundamentally from that now used by most anthropologists. According to this method the assignment of sex is the *result* of the measurements, rather than being made prior to the measurements. The difference can be made clear if one considers what would be done if another specimen were added to the series. Traditionally, the sex of the bone would be guessed and then the measurements taken. By the method described in this paper, the measurements are taken first, the position of the specimen in the series is determined, and finally an estimate of the sex is given. The importance of the difference in procedure arises from two sets of factors. If sex is assigned first, then the measurements can do no more than quantify the opinion of the person who guessed the sex. The investigator may be right most of the time, but this can not be proved because all the observer's biases are incorporated into the original sorting. Second, if sex is assigned, it is not known why any particular individual was put into one category rather than the other. Any one of the many criteria may have been used, and, although a good morphologist is probably nearly always correct in his designation, he can neither teach others nor improve his methods, except

in the sense that an art can be taught and improved. The present method can be easily taught, and can be improved by devising measurements which separate the sexes more effectively or by adding additional, uncorrelated measurements. In short, the method recommended here is more useful than the traditional anthropological one of depending on personal judgment because: the basis for the assignment of sex is explicit and can be improved, a beginner can do as well as an expert, and it automatically adjusts to the variations in new series.

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THIGH GIRTH AS A MEANS FOR EVALUATION OF NUTRITIONAL STATUS

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DIFFERENT methods have been employed to evaluate the nutritional status of a person, including classical anthropometry, specific gravity determinations, and X-ray pictures. The caloric aspect of nutritional status may be evaluated best by considering the fatness of the body estimated from specific gravity. But such a determination is a long and complex procedure. X-rays may show the thickness of skin and subcutaneous fat very well; but, again, the procedure is very expensive and the delineation between skin and fat is not possible. Thus the use of an adequate, simple anthropometric method still has a rational basis.

In addition to determining body weight (gross and related to age and stature) two techniques seem to be useful: (1) measuring skinfolds by a special caliper; (2) measuring circumferences. Unfortunately, there still is no standardized caliper available and a standard method of measuring skinfolds is lacking. The technique of measuring circumferences, however, is fairly standardized and simple and may yield fair results when measurements are considered in relation to some other measurement such as height or weight.

The data discussed in the present paper were obtained on 311 men 18-23 years old and 435 women 17-23 years old in the central medical clinic of the schools of Ljubljana (Škerlj, '50). The measurements were taken during the academic year 1939-40, the last normal year in Yugoslavia prior to the Italian and German occupation. In the program of systematic measurements of the secondary school and college youths of Ljubljana, chest, waist and thigh girth were measured with a tape. The chest girth was measured high on the thorax, just below the axillae and always somewhat above the nipples, so that it was possible to measure it in both sexes in the same way. Maximum (after inhaling) and minimum

(after exhaling) values were determined and averaged. The waist girth was measured above the navel to get the minimum circumference of the trunk. Neither of these measurements can be taken with high certainty and therefore were recorded to the nearest 0.5 cm only. The thigh girth was measured (in mm) around the thickest part of the thigh in the middle of the upper third. The subjects stood with the weight on the measured limb, normally the right one.

In order to ascertain the usefulness of the measurements, the "constitutional" type was determined in both sexes; in females the "plastic" type and the size of the breasts also was considered. "Constitutional" types were labelled "leptosomatic," "mixed," and "eurysomatic"; the "plastic" types, referring to the body mass evaluated by inspection, were labelled "hypo-," "normo-," and "hyper-plastic." The size of the breasts was rated on a 5-point scale.

To find out which of the three circumferences may be the best for evaluating the nutritional status, various correlations were calculated. The results are given in Table 1.

RESULTS

1. In males, chest girth has the highest correlation with stature, and thigh girth the lowest; in females, waist girth has the lowest correlation. All coefficients are rather low.

2. In both sexes, chest girth has the lowest correlation with weight, thigh girth the highest. The coefficients in females are somewhat higher than in males.

3. In both sexes, the correlation between thigh girth and chest girth is lower than between thigh and waist or between chest and waist.

4. Chest girth has the highest correlation with "constitutional" types in both sexes.

5. Of all the measurements, thigh girth shows the highest correlation with "plastic" type.

6. The correlation of the size of the breasts with thigh girth is somewhat greater than with chest and waist girth.

In anthropometric studies chest and waist girth are usually given. But we know that both not only measure bones and soft tissues (muscles and fat), but also the variable volume of some of the viscera; the abdomen may be distended, or the lungs may contain more or less air. Even on *a priori* grounds, the thigh girth therefore seems to be a better indication

of the nutritional status of the subject measured. Very probably the same is true of the upper arm girth (Brožek and Keys, '51 and Lasker, '52).

TABLE 1

Correlations of the girths with other characteristics

Correlations	311 18–23 year old males	435 17–23 year old females
Stature width		
chest girth	.311 ± .034	.299 ± .029
waist girth	.256 ± .036	.168 ± .031
thigh girth	.246 ± .036	.215 ± .031
Weight width		
chest girth	.756 ± .016	.809 ± .011
waist girth	.795 ± .014	.824 ± .014
thigh girth	.854 ± .010	.864 ± .008
Chest with waist girth	.669 ± .021	.789 ± .012
Chest with thigh girth	.620 ± .023	.672 ± .018
Waist with thigh girth	.670 ± .021	.726 ± .015
"Constitution" with		
chest girth	.537 ± .027	.430 ± .026
waist girth	.412 ± .032	.376 ± .028
thigh girth	.381 ± .033	.402 ± .027
"Plastic" type with		
chest girth		.473 ± .025
waist girth		.488 ± .025
thigh girth		.630 ± .019
Size of breasts with		
chest girth		.387 ± .028
waist girth		.406 ± .027
thigh girth		.422 ± .027

The advantages of measuring the thigh girth are clear: it is a rapid, simple, and inexpensive anthropometric method; when measured, the subject can be dressed in underwear or a bathing suit; the correlation with weight is high; even the correlation with the "plastic" types and with the size of the breasts (in females) is quite high. This latter statement is important insofar as the "hyper-plastic" type and the size of the mammae are highly conditioned by fat tissue—as is the circumference of the thigh. As Brožek and Keys ('50) stated, in evaluating

"normal" weight, we have to know what we are weighing; one may say the same about measuring circumferences for the purpose of evaluating leanness-fatness. From this point of view it seems that the upper arm and the thigh girth are the best simple anthropometric measures to appraise individual nutritional status. For the present reference sample one would say that (using plus and minus two standard deviations from the mean as limits) men having a thigh girth relative to stature lower than 27 could be considered as lean, those having more than 36 as fat. In women, the mean thigh girth relative to stature is about 35; if it is lower than 29 the subject may be regarded as lean, if more than 41 as fat.

There are two minor disadvantages inherent in this method. The measurement is made near the sexual organs and it is therefore necessary to exercise great tact. Pressure of the tape can be highly arbitrary and it seems best to measure without pressure on the tape. From measuring thigh girth, one can say nothing about the relation of muscle tissue to fat. Better than any other simple measure, however, thigh girth enables one to consider the nutritional status according to the development of the subject's soft tissues as a whole.

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THE DEVELOPMENT OF SEX DIFFERENCES IN BODY DIMENSIONS, EVALUATED IN TERMS OF THE CRITICAL RATIO

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ON the average, the adult man is bigger than the adult woman—his shoulders are broader, the thorax more voluminous, etc. How and when do these differences develop? Even though longitudinal studies have unquestionable advantages, some of these questions can be answered by the use of critical ratios which serve to test the significance of differences between measurements in cross-sectional studies.

TABLE 1

Size of the age groups

	AGE IN YEARS										
	11	12	13	14	15	16	17	18	19	20-23	Total
Boys	75	95	130	147	116	100	104	116	100	114	1097
Girls	94	171	247	260	253	133	137	157	107	54	1613

The present study refers to children of secondary schools and colleges of Ljubljana who were investigated during the academic year 1939-40 (Škerlj, '50). The ages were 11 to 23 years (see Table I). Measurements were taken by standard technique (Martin, '28), except the chest girth which was measured, in both sexes, high in the axillae and above the nipples. The measurements include the following: stature, weight, head length and breadth, bi-acromial, bi-cristal, and bi-trochanteric widths, chest, waist, and thigh girths, and vital capacity (by Hutchinson's spirometer). From these measurements some indices and relative measurements were derived. The children were a random sample of healthy school youth of Ljubljana.

The data were evaluated by calculating the means, the differences between means (D), and their probable errors (PE). The critical ratios (D/PE) were considered significant when the ratio was between 3 and 4.5, and highly significant when it exceeded 4.5. The direction of the

TABLE 2

Development of sex differences

Characters	AGE IN YEARS 11	12	13	14	15	16	17	18	19	20-23
Head length	B	B	B	B	B	B	B	B	B	B
Head breadth	B	b	B	B	B	B	B	B	B	B
Cephalic index	o	o	o	o	o	o	o	g	o	o
Weight	g	o	G	G	o	b	B	B	B	B
Stature	o	o	g	o	B	B	B	B	B	B
Rohrer's index	o	o	o	G	G	G	G	G	G	G
Bi-acromial width	o	o	o	o	B	B	B	B	B	B
Rel. bi-acromial width	B	o	B	b	o	b	b	B	b	B
Bi-cristal width	o	G	G	G	G	g	g	o	o	o
Rel. bi-cristal width	o	G	G	G	G	G	G	G	G	G
Bi-trochanteric width	G	G	G	G	G	G	G	o	o	o
Rel. bi-trochanteric width	G	G	G	G	G	G	G	G	G	G
Chest girth	b	o	o	o	b	B	B	B	B	B
Rel. chest girth	B	b	B	o	o	o	o	o	o	b
Waist girth	o	o	o	b	o	B	B	B	B	B
Rel. waist girth	o	o	o	o	g	o	o	o	G	o
Thigh girth	g	G	G	G	G	G	G	G	G	G
Rel. thigh girth	o	g	g	G	G	G	G	G	G	G
Lorentz' spiroindex	B	B	B	B	B	B	B	B	B	B

Rohrer's index gives the relation between stature and weight by the formula $\frac{\text{weight, in gm}}{\text{stature}^3\text{, in cm}} \times 100$. "Rel." means the respective measurement relative to stature. Lorentz' spiroindex gives the relation of the exhaled air in cm^3 per cm of stature.

differences is indicated by the use of small (b, g) and capital letters (B, G), respectively. The letter indicates the sex in which the means are larger (B for boy, G for Girl). Small o indicates the absence of a significant difference. The results are presented in Table 2.

The absolute length and breadth of the head is significantly higher

in boys during the whole period of observation. Except at 11, 13, 14, and 15 years of age, the girls' cephalic indices are slightly higher.

Weight is significantly greater in girls in the 13th and the 14th year, in boys, from the 16th year on. Stature is slightly greater in girls in the 13th year, but from the 15th year on, boys are significantly taller. Rohrer's index is significantly higher in girls from the 14th year on.

In widths the sexual differences are very interesting. As could be expected, the absolute measurements do not show the same trends as the relative values. The absolute bi-acromial width is significantly higher in boys from 15 years on, the absolute bi-cristal width in girls from the 12th to 15th year of age. The latter is slightly higher in girls till the 17th year when the sex difference disappears. This is in agreement with the faster growth of girls in the first half of the period under consideration. Similarly, the absolute bi-trochanteric width is higher in girls from 11 to 17 years; *later there is no sex difference.*

In girls the relative bi-acromial width tends to be lower than in boys. The relative bi-cristal width is significantly higher in girls from the 12th year on, whereas the relative bi-trochanteric width is higher in girls throughout the whole period.

In boys, the absolute chest and waist girths are definitely higher from the 16th year on. The absolute thigh girth is higher in girls throughout. In the circumferences relative to stature, boys tend to have a larger chest, girls a larger waist circumference but the sex differences are not very marked. The relative thigh girth is insignificantly higher in girls in the 11th year; the difference is slightly significant in the 12th and 13th years, and highly significant from the 14th year on. Finally, Lorentz' spiroindex indicates a significant sex difference throughout the whole period, with the boys having higher values even during the period when girls develop faster (11th to 15th year).

Some anthropometric sex differences are present even before the pubertal age, some only thereafter. Absolute head length and breadth as well as Lorentz' spiroindex, in boys, relative circumferences of hips and thighs, in girls, are significantly larger from 11 years to maturity. The cephalic index and the relative waist girth are, broadly speaking, *sexually indifferent characters.* Stature, Rohrer's index, bi-acromial width, relative bi-cristal width, absolute chest and waist girth *become significantly different during puberty.* Absolute bi-cristal and bi-trochantric widths as well as relative chest girth *become sexually indifferent characters after 18 years of age.* The sex differences in weight reverse themselves around the age of 15 years.

Of the 19 characters investigated, seven are significantly different in the 11th year, six in the 12th, eleven in the 13th and 14th years, twelve in the 15th year, thirteen in the 16th year, and fourteen from the 17th year on.

The results obtained in this investigation contribute to our knowledge of the development of secondary sex differences during the prepubertal, pubertal and early adult ages. Similar studies of other characters in subjects of this age range as well as the investigation of children during the first decade of life would throw additional light on the development of sex differences.

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PREVALENCE OF LEFT-HANDEDNESS AMONG SELECTIVE SERVICE REGISTRANTS

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INTRODUCTION

THE findings presented here on the prevalence of left-handedness among Selective Service registrants examined for military service are based on information obtained from the "Report of Medical History" (Standard Form 89). These individual reports are accomplished at the examining induction stations at the time the registrants are given a medical examination to determine their fitness for military service. The established procedures for the medical processing of registrants require that a medical history be taken on each examinee (Special Regulations, '51).

This report form is designed primarily to provide data on the examinee's health status (past and present) and also some similar data regarding his blood relations and other relatives. The questions on the form are therefore predominantly medical. The medical information reported on the form is used by the examining physician as a reference when conducting the medical examination. Specifically, it serves to alert the physician to conditions or ailments which ordinarily are not readily discernible.

In addition to the questions about health, the form contains questions regarding the examinee's occupation, employment, and some personal characteristics. Among the last group of questions, is the following question:

"Are you (check one) ☐ Right handed ☐ Left handed."

GENERAL CONSIDERATIONS

The "Report of Medical History" is a self-administered paper-and-pencil form. It is filled out by the examinee in his own handwriting. Neither oral nor written instructions are given for completing the form. Assistance is provided only whenever the registrant has difficulty in understanding the questions; such difficulty arises chiefly with respect to unfamiliar medical terms used on the form.

The reliability of information obtained from this type of form depends, of course, on whether the respondent is able and willing to supply the correct answers to the questions. The respondent may not know the right answer. In the case of the Report of Medical History, it may be especially true with respect to certain medical questions. On the other hand, the respondent may know, but for some reason(s) be unwilling to supply the right answer. This may be true of questions on the form dealing, for instance, with undesirable habits or traits of character (e. g homosexuality, chronic drunkenness, etc.). In these cases, the type of answer may be adversely motivated either by certain social factors (stigma attached to such traits, etc.), or by the individual's desire or lack of desire to be accepted for military service. However in regard to the particular question on handedness, there seems to be no basis to doubt the individual's ability or willingness to give the correct answer.

The answer to this question is what the individual registrant considers himself to be: either right-handed or left-handed. In view of the fact that we are dealing here with an adult group, this particular self-appraisal formed by the individual on the basis of his own experience may be assumed to be generally accurate. It may be also assumed that the information is generally free of bias, in the sense that the answer to the question may be taken as being genuine, since handedness *per se* is not a factor in determining the individual's acceptablity for military service—a fact presumably well-known to the examinee.

This investigation evolved from an inquiry made to the Office of The Surgeon General, Army, as to the proportion of left-handed individuals among personnel of the Armed Forces. It appeared from this inquiry that the information might possibly be used as an index of the prevalence of left-handedness in the total population. Though left-handedness as such is not disqualifying for military service, as previously noted, past studies on left-handedness seemed to suggest that it might be associated to a certain extent with some physical or mental conditions

(Wile, '34) which might be of disqualifying nature. To preclude therefore possible bias that could result from limiting the investigation to Army (qualified) personnel, the study was broadened to include both registrants who were qualified and those who were disqualified for

TABLE 1

Prevalence of left-handedness among qualified and disqualified registrants examined at armed forces examining stations, Continental United States, by army area, 1952 [1]

ARMY AREA[2]	QUALIFIED (INDUCED)		DISQUALIFIED	
	Total Number (1)	Number Left-Handed (2)	Total Number (3)	Number Left-Handed (4)
I	1,187	91	610	70
II	1,180	93	1,238	130
III	836	60	1,487	133
IV	530	36	1,233	101
V	1,788	148	759	82
VI	519	43	792	77
Total	6,040	471	6,119	593

[1] Source: Standard Forms 89 ("Report of Medical History"), received by the Department of the Army during the following dates: 19 June, 28 June and 30 June, 1952.

[2] States within each army area are as follows: *First Army Area*—Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont; *Second Army Area*—Delaware, District of Columbia, Kentucky, Maryland, Ohio, Pennsylvania, Virginia, and West Virginia; *Third Army Area*—Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee; *Fourth Army Area*—Arkansas, Louisiana, New Mexico, Oklahoma, and Texas; *Fifth Army Area*—Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin, and Wyoming; *Sixth Army Area*—Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, and Washington.

military service. The information was abstracted by means of a hand tabulation from the Standard Forms 89 ("Report of Medical History") that were received by the Department of the Army during the following dates: 19 June, 28 June, and 30 June, 1952.

The obtained data are shown in Table 1.

PREVALENCE RATES BY ARMY AREA AND CHI-SQUARE ANALYSIS

Slightly over 12,000 forms from the Continental United States were hand-tabulated. The tabulation was made separately for the qualified group and the disqualified group (sample groups), and each of these groups was stratified by army area (sample components). (The Continental United States are separated into six army areas which roughly correspond to the geographic subdivisions used by the Bureau of the Census. The states included in each army area are specified in the second footnote to Table 1.)

Because of possible differences in the prevalence of left-handedness between these groups, the prevalence rate of each army area within the qualified group and the disqualified group was computed, prior to deriving rates reflecting the prevalence of left-handedness among all registrants (qualified plus disqualified). A chi-square analysis was then undertaken to determine whether any statistically significant differences exist between the rates of the following sample components: *a.* Between army areas within the qualified group; *b.* between army areas within the disqualified group; and *c.* between the qualified and the disqualified components of each army area and all army areas combined.

As seen from Table 2, the prevalence of left-handedness by army area within the qualified group ranged from 6.8 percent in the Fourth Army Area to 8.3 percent in the Fifth and Sixth Army Areas. However, a chi-square analysis of these rates indicate that the probability (P) of obtaining a chi-square value equal to or greater than that obtained for the qualified group by army area was as large as approximately .85 ($.90 > P > .80$; Table 3, A). In other words, the derived chi-square values indicated a very high probability that the variations between these rates by army area could have arisen by chance alone.

For the disqualified group, the prevalence rates of left-handedness ranged from 8.2 percent in the Fourth Army Area, to 11.5 percent in the First Army Area (Table 2, B). In this case, the probability (P) of securing by chance a chi-square value as great or greater than that obtained for the disqualified group was approximately .15 ($.20 > P > .10$; Table 3, B).

Neither of these groups thus indicated statistically significant differences by army area, either at the 1 percent or 5 percent level of significance. It means that no statistically significant geographic differentials, as determined by army area, were found in the prevalence of left-

TABLE 2

*Prevalence of left-handedness among registrants in the Continental United States processed for military service: a. qualified; b. disqualified, and c. total examined (qualified and disqualified), by army area, 1952.**

ARMY AREA AND GROUP	PREVALENCE IN PERCENT		
		Confidence Intervals	
	Percent Left-handed	Confidence Coefficient 0.95	Confidence Coefficient 0.99
	(1)	(2)	(3)
A. Qualified (Inducted)			
I	7.7	6.2– 9.3	5.8– 9.9
II	7.9	6.4– 9.6	6.0–10.1
III	7.2	5.5– 9.1	5.1– 9.8
IV	6.8	4.8– 9.3	4.3–10.1
V	8.3	7.0– 9.7	6.7–10.1
VI	8.3	6.1–11.0	5.5–11.9
Total U. S.	7.9	7.2– 8.5	6.9– 8.8
B. Disqualified			
I	11.5	9.1–14.3	8.4–15.2
II	10.5	8.8–12.3	8.3–13.0
III	8.9	7.5–10.5	7.1–11.0
IV	8.2	6.7– 9.9	6.3–10.4
V	10.8	8.7–13.3	8.1–14.1
VI	9.7	7.8–12.0	7.2–12.7
Total U. S.	10.1	9.3–10.9	9.0–11.2
C. Total Examined (Qualified & Disqualified)			
I	8.7	7.4–10.0	7.0–10.4
II	8.8	7.6– 9.9	7.2–10.3
III	8.1	6.9– 9.2	6.6– 9.6
IV	7.4	6.0– 8.8	5.5– 9.2
V	8.9	7.8–10.0	7.4–10.4
VI	8.8	7.1–10.5	6.6–11.0
Total U. S.	8.6	8.0– 9.1	7.9– 9.3

* See "Technical Note," at the end of the article.

handedness among analogous (qualified or disqualified) groups of registrants.

Different results however, were obtained when the prevalence rate of each army area in the qualified group was compared with the corresponding rate of the army area in the disqualified group. In analyzing these rates, three army areas (First, Second, and Fifth) showed chi-square values that were statistically significant at least at the 5 percent level of significance. In the other three army areas (Third, Fourth, and Sixth), none of the chi-square values reached the value corresponding

TABLE 3

Chi-square values *

GROUP TESTED	χ^2	DEGREES OF FREEDOM	PROBABILITY (P)	LEVEL OF STATISTICAL SIGNIFICANCE 0.05	0.01
A. Qualified (by Army Area)	1.977	5	.90 >P>.80	—	—
B. Disqualified (by Army Area)	8.337	5	.20 >P>.10	—	—
C. Qualified vs. Disqualified:					
a. Individual Samples:					
First Army Area	7.167	1	.0077>P>.0073	+	+
Second Army Area	4.952	1	.0269>P>.0254	+	+
Third Army Area	2.194	1	.1473>P>.1380	—	—
Fourth Army Area	1.012	1	.3173>P>.2943	—	—
Fifth Army Area	4.140	1	.0429>P>.0404	+	—
Sixth Army Area	.779	1	.3802>P>.3771	—	—
b. Total (Pooled samples)	13.643	1	.001 >P> 0	+	+
c. Total (Sum of χ^2 of the individual components)	20.244	6	.01 >P>.001	+	+
d. Interaction χ^2 value	6.601	5	.30 >P>.20	—	—

* Relate to the data of Table 1. The chi-square values for "Qualified (by Army Area)" and "Disqualified (by Army Area)" were calculated by the Brandt and Snedecor Method. (See: Snedecor, '50: "A special method of computing chi-square in R × 2 table," pp. 205-206.) For the method used in computing the chi-square values of Qualified vs. Disqualified and a general discussion of chi-square values derived from a pooled sample versus chi-square values obtained by summing the chi-square values of the individual samples, see Snedecor, ('50), pp. 188-193, or Ferber, ('49): pp. 266, 270-275. The "P" values for 1 degree of freedom were taken from Yule and Kendall, ('48): pp. 534-535. Plus sign (+) means "significant" and minus sign (—) means "nonsignificant," at the particular level of significance.

to 1 percent or 5 percent level of significance (Table 3, Ca). However, all differences were in the same direction; that is, each army area in the disqualified group showed a higher prevalence of left-handedness than that shown by the same area in the qualified group (Table 2).

The chi-square value obtained in comparing the over-all (all area combined) prevalence rate of the disqualified group with the over-all rate of the qualified group was larger than the chi-square value for 1 percent level of significance. This held true when the chi-square value was computed by pooling the samples (Table 3, Cb), or by summing the individual chi-square values (Table 3, Cc). The obtained chi-square values of the over-all rates thus indicated that the prevalence of left-handedness among disqualified registrants was significantly higher than among the qualified registrants. The validity of this statement was further corroborated by the fact that the interaction chi-square value was much below that of the 5 percent level of significance ($.30 > P > .20$; Table 3, Cd); this fact suggests that we are dealing with homogeneous populations. (See Snedecor, '50, pp. 188-193.) Restating, the obtained chi-square values strongly suggest that there exist real differences between the prevalence of left-handedness in the disqualified group and that in the qualified group.

ADJUSTMENT FOR DISPROPORTIONALITY

The significantly higher prevalence of left-handedness found among disqualified registrants, when compared with the prevalence rate among qualified registrants, seemingly confirms former findings which have suggested certain association between left-handedness and some physical or mental abnormalities. But apart from this fact by itself, these differences are of importance in the computational sense; namely, in deriving the prevalence rate for the combined (qualified plus disqualified) sample components.

For sample control purposes, distributions of qualified and disqualified registrants, by army area, were obtained from the results of the preinduction examinations of registrants processed during the six-month period from January 1952 through June 1952. These relative distributions are presented in Table 4, under the heading "population," as follows: *a.* Qualified group, by army area; *b.* disqualified group, by army area; *c.* qualified versus disqualified in each army area and all army areas combined. The corresponding distributions obtained from the sample are

shown in Table 4, under the heading "sample." In comparing these relative distributions, it readily became evident that the forms in the sample were disproportionately distributed, especially in the relative ratios of qualified to disqualified. For instance, the ratio of "Total U. S.: Qualified" to "Total U. S.: Disqualified" registrants obtained from the sample groups was about 1:1, while the corresponding ratio in the population was about 7:3 (Table 4, Column 3). Analogous differences were noted in the ratios of qualified to disqualified of the individual army areas. Variation in these ratios was expected because of the following fact: Standard Forms 89 of disqualified registrants are received immediately after the preinduction examinations, while those of qualified registrants are received after induction, which takes place at some time after the preinduction examinations. Evidently, this difference in procedure of forwarding the forms may bring about, at any particular point in time, ratios of "qualified" (inducted) to "disqualified" that are different from their original ("population") ratios at the time of preinduction examinations.

Because of these disproportionalities and due to the fact that there were found significant differences between the prevalence of left-handedness in the two groups, the prevalence rates of the combined (qualified plus disqualified) components, whether for each individual army area or all areas, could not be computed by directly combining the corresponding data, as obtained from the sample, without adjusting for disproportionality. Certain disproportionalities were also found in the relative distribution by army area of the qualified group and likewise of the disqualified group. For instance, in the qualified group the First Army Area constituted about 20 percent of the sample-group, while in the "population" this area made up about 23 percent of the total qualified group; in the disqualified group, the First Army Area constituted about 10 percent of this group in the sample, as against 17 percent in the population. (Table 4, Columns 1 and 2). Since no statistically significant differences were found between the rates of the army areas within each of these groups, as stated above, the disproportionalities by army area are naturally of less importance in computing over-all rates for the groups.

The following rates were adjusted for disproportionality: *a.* Over-all rate of the qualified group; *b.* over-all rate of the disqualified group; and *c.* combined rates (qualified plus disqualified) of each army area and all army areas. (These rates may be referred to as "weighted"

rates, and all other rates as "unweighted." The procedures applied in adjusting for disproportionality are explained in the "Technical Note," at the end of the article.)

TABLE 4

Relative distributions of qualified and disqualified registrants by army area, and ratios of qualified to disqualified registrants within each army area and for total United States

ARMY AREA	RELATIVE DISTRIBUTION BY ARMY AREA (PERCENT)		RATIOS FOR 1,000 EXAMINED, WITHIN EACH ARMY AREA AND FOR TOTAL U. S.
	Qualified (1)	Disqualified (2)	Qualified vs. Disqualified (3)
Population [1]			
I	22.68	17.24	730: 270
II	18.18	18.71	667: 333
III	10.00	21.43	490: 510
IV	6.88	10.23	580: 420
V	34.79	23.45	753: 247
VI	7.47	8.94	632: 368
Total U. S.	100.00	100.00	673: 327
Sample [2]			
I	19.65	9.97	661: 339
II	19.54	20.23	488: 512
III	13.84	24.31	360: 640
IV	8.77	20.15	301: 699
V	29.61	12.40	702: 298
VI	8.59	12.94	396: 604
Total U. S.	100.00	100.00	497: 503

[1] Based on preinduction examinations of registrants processed during the six-month period from January 1952 through June 1952.

[2] Derived from Table 1.

All (weighted and unweighted) rates are given in Table 2 together with their confidence intervals based on the 0.95 and 0.99 confidence coefficients. (See Mainland '52, pp. 53-56, or any standard book on statistics, for interpretation of confidence intervals, and the "Technical Note," at the end of the article, for the computation of the confidence intervals.)

OVER-ALL RATES

The over-all prevalence rates and their confidence intervals were found to be as follows (Table 2):

a. Qualified—Total U. S.: 7.9 percent of this group of registrants reported as being left-handed. The confidence intervals are 7.2 percent-8.5 percent for 0.95 confidence coefficient, and 6.9 percent-8.8 percent for 0.99 confidence coefficient.

b. Disqualified—Total U. S.: 10.1 percent of this group of registrants reported as being left-handed. The corresponding confidence intervals are 9.3 percent-10.9 percent, and 9.0 percent-11.2 percent, for 0.95 and 0.99 confidence coefficients, respectively.

c. Qualified and Disqualified—Total U. S.: 8.6 percent of all registrants examined were found to be left-handed. The corresponding confidence intervals are 8.0 percent-9.1 percent, and 7.9 percent-9.3 percent for 0.95 and 0.99 confidence coefficients, respectively.

It should be noted that these rates relate to examined registrants within the 19 through 25 age-group. As known, certain groups of registrants are in the deferred classes because of marital status, dependency, occupational specialties, etc., and are not sent for examination. However, judging from the above-stated bases for deferment, there is no reason to believe that there is selection with respect to the prevalence of left-handedness among the registrants forwarded for examination. Consequently, the derived prevalence rates of 8.6 percent may presumably be taken as reflecting the prevalence of left-handedness among all registrants. Moreover, this rate may seemingly be taken as representing the prevalence of left-handedness among the total male population in the Continental United States, beginning with the age when handedness may generally be considered fixed. (Past studies on left-handedness report prevalence rates ranging from 1 to 30 percent of the population; See Wile '34, p. 68; also Hildreth '49.)

SUMMARY

1. Information on the prevalence of left-handedness among Selective Service registrants was obtained from the "Report of Medical History," a form filled out by each registrant at the time he is examined for determining his fitness for military service. It is a self-administered

paper-and-pencil form designed primarily to secure information on the examinee's past and present health status. One of the questions on the form is: "Are you (check one) ☐ Right handed ☐ Left handed."

2. About 12,000 forms were hand-tabulated in this investigation; the forms were about equally divided between the group of registrants found fit for military service (inductees) and the group of registrants found unfit for such service. The forms were tabulated by army area within each of these groups.

3. The following over-all prevalence of left-handedness was found:

   a. Qualified—7.9 percent left-handed;
   b. Disqualified—10.1 percent left-handed;
   c. Total (qualified plus disqualified)—8.6 percent left-handed.

4. A chi-square analysis of these rates revealed that the difference between the higher prevalence rate of left-handedness among the disqualified registrants and that among the qualified registrants is statistically significant. (The probability of obtaining a chi-square value as large or larger than the value obtained in this case was less than .01.) Since left-handedness *per se* is not disqualifying for military service, this seems to suggest that left-handedness might be associated with certain defects which are of a disqualifying nature.

5. No statistically significant differences were found among the prevalence rates of the individual army areas in either of the groups, qualified or disqualified.

6. The total prevalence rate of left-handedness (8.6 percent) found among examined registrants may be taken as representative of all registrants. This rate relates to an adult male U. S. population.

7. The information obtained on handedness reflects what the registrant considered himself to be: right-handed or left-handed.

8. This investigation was limited in scope. There still remains the wider question: If it is true that the prevalence of left-handedness is significantly higher among the disqualified registrants than among qualified registrants, then what are the particular defects or diagnoses with which left-handedness is associated?

TECHNICAL NOTE

1. *Weighted Rates and Weighted Variances. a. General.* As pointed out in the text, samples of two separate groups were taken in investigating the prevalence of left-handedness among examined registrants: one

relating to the prevalence of left-handedness in the qualified (inducted) group of registrants; the other relating to that in the disqualified group. Each of these sample-groups was stratified by army area (Table 1). In examining the number of forms obtained for each army area within each group, it was found that their relative distribution differed from the corresponding relative distribution by army area in the population. (See Table 4, Columns 1 and 2, for comparative distribution of these groups in the sample and in the population.) Consequently, in deriving the over-all prevalence rate of left-handedness for each group (Qualified —Total U. S.; Disqualified—Total U. S.), the rates of left-handedness of the individual army areas (sample components) within each group were weighted according to their relative distribution in the population, in order to correct for the disproportionality in the relative distributions of the sample. Likewise, the variances of the individual army area rates were adjusted for disproportionality.

The over-all group-rates and their standard errors were derived by means of the following formulas:

(1) $\sum w_i p_i$ —used for computing the over-all group-rate, where w_i (population proportion) signifies the relative proportion of the particular component in the population, and p_i represents the proportion of left-handedness in the particular component as found in the sample;

(2) $\sigma_p = \sqrt{\sum \frac{w_i^2 p_i q_i}{n_i}}$ —represents the standard error of a proportion of a disproportionate sample, where w_i and p_i have the same meaning as in formula (1) above; $q_i = 1 - p_i$; and n_i is the number in the particular sample-component. (See Ferber '49, pp. 89-90 and 137-142, for a general discussion on disproportionate samples.)

b. Qualified: Total U. S. For this group: w_i represents the population proportion of the qualified group in any particular army area, as given in Table 4, Column 1 (Population); p_i is the proportion of left-handed as given in Table 2, Column 1 (Qualified); n_i is the number obtained for the particular army area as given in Table 1, Column 1. For example, in case of the First Army Area: $w_i = .2268$; $p_i = .0767$; $q_i = .9233$; and $n_i = 1{,}187$. To obtain the over-all group-rate (Qualified: Total U. S.), the $w_i p_i$ (weighted proportions of left-handedness) of each army area were computed, summed up, and expressed in terms of percent.

The standard error (σ_p) of the over-all rate was derived by summing the individual $\frac{w_i^2 p_i q_i}{n_i}$ (weighted variances) of the army areas, and extracting the square root of the obtained sum. The standard error (σ_p), expressed in percent, was then used in calculating the confidence limits for the "Qualified: Total U. S." (See 3, below.)

c. Disqualified: Total U. S. The same procedures, as those described in *b* for the "Qualified" group, were followed in computing the necessary statistics for this group. The individual w_i for this group is given in Table 4, Column 2 (Population): p_i in Table 2, Column 1 (Disqualified); and n_i—Table 1, Column 3. The corresponding data for the First Army Area, for example, were: $w_i = .1724$; $p_i = .1148$; $q_i = .8852$; and $n_i = 610$.

d. Combined: Examined (Qualified plus Disqualified). Since the ratios of "qualified" to "disqualified" in the samples were also found to be different from their relative distributions in the population, the problem of disproportionality was encountered in computing the combined prevalence rates (qualified plus disqualified) for each army area and for all army areas, as well as in deriving the confidence limits for these rates. (Compare the relative ratios as given in Table 4, Column 3, for the sample and the population.) The above-stated formulas (*a*, above) were, therefore, used in computing total prevalence rates and the standard errors of the combined rates for each individual army area, as well as of all army areas. For these groups, w_i is the respective ratio of the number qualified to the number disqualified as given in Table 4, Column 3 (Population): p_i is the respective proportion of left-handedness (Table 2, Column 1); n_i is the respective number (Table 1, Columns 1 and 3). Using the First Army Area again as an illustration, w_i are: .730 and .270; p_i—.0767 and .1148; q_i—.9233 and .8852; and n_i—1,187 and 610, for qualified and disqualified components, respectively.

2. *Unweighted rates.* The standard errors of the rates of the individual army areas within the qualified group or disqualified group were computed by the standard formula for proportions: $\sigma_p = \sqrt{\frac{p_i q_i}{n_i}}$

3. *Confidence Intervals. a. Unweighted rates.* The confidence intervals for the unweighted rates were computed by the following formula adapted from Mainland ('48) pp. 25-26, for $p \leq 0.1$:

$$(A \pm F\sqrt{Aq} + \text{appropriate correction term})/n,$$

where A is number of A's in the sample (in our case, the number left-handed); F is the number of standard errors required for the particular confidence coefficient, i. e., 1.96 and 2.58 for 0.95 and 0.99 confidence coefficients, respectively; $q = 1 - p$, where p in our case is the proportion of left-handed in the sample; the appropriate correction term is as given in Mainland ('48), Table III, p. 135; and n is the sample size.

Expressed in our terminology, the above-stated formula is:

$$p_i \pm F\sigma_p + \text{correction term}/n.$$

For $p > 0.1$, the confidence intervals were computed by interpolation from Mainland ('48), Table II, p. 131.

b. Weighted Rates. For the weighted rates (total qualified; total disqualified; and the combined rates for qualified plus disqualified for each army area and all army areas), no correction term (*a*, above) was used in computing the confidence limits. (See Snedecor, '50, p. 193.)

ACKNOWLEDGMENT

Acknowledgment is made to the following persons in the Office of The Surgeon General for their assistance in this study: Mrs. Grace Souther, Chief, Induction Examination Records Branch, and Messrs. E. A. Confrey, M. Kupperman, A. L. Ranofsky, and F. Reister, Statistical Analysis Branch.

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THE AGE FACTOR IN BODILY MEASUREMENTS OF ADULT MALE AND FEMALE MEXICANS[1]

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DURING a study of adult Mexicans it was noted that there are significant decreases with age in such overall dimensions as stature and sitting height, and increases with age in chest dimensions and various measurements of the head and face. Of course it has long been known that growth does not cease at some fixed age. As early as 1899, Pfitzner measured large series of adults and showed changes with age in stature, sitting height, the head dimensions, bizygomatic diameter and face height. Nevertheless, it has been customary in anthropological studies of race to treat data on all individuals over some arbitrary age (usually 18 years) as comparable (Martin '28). It would be desirable to take the age factor into account.

The purpose of the present paper is to indicate to what extent comparisons of measurements on groups of unrelated adults are affected by differences in the ages of the individuals. For this purpose one series has been selected to represent a single small community, Paracho, Michoacán, Mexico. With the hope of limiting the range of environments involved, a random sample of individuals who had never migrated from Mexico is used. For comparison with these 268 sedentes measured by the author in Paracho in 1948, a series of 608 adults measured in various parts of Mexico by Goldstein ('43) is utilized.

[1] The support of field work in Mexico by the Wenner-Gren Foundation for Anthropological Research and the assistance of Prof. Pablo Velasquez G. and Miss Bernice Kaplan is gratefully acknowledged. Dr. M. S. Goldstein kindly made his original records available and has read the manuscript and offered valuable criticisms.

METHODS

The techniques of measurement are described elsewhere (Lasker '52, and Goldstein '43). In comparing the data of Lasker with those of Goldstein or others, it is well to bear in mind that there are probably personal differences in the definition of landmarks and the techniques of measurement. Absolute measurements, therefore, are not compared directly. The personal equation, however, should not greatly influence the comparison of differences. In the descriptions of the findings which follow, categorical statements of a difference or use of the phrase "significantly different" refer to mean differences of at least twice the standard error; while "tendency" refers to differences not reaching this level of significance. The age curves for various measurements are recorded in Figures 1 to 4. In the graphs, solid lines pertain to Lasker's data; broken lines to Goldstein's; solid circles indicate males; open circles indicate females. In Lasker's material age is recorded to the last birthday; Goldstein ('43, p. 35) recorded age to the nearest birthday. Not all individuals were measured in every dimension: head height, especially, was omitted in many of Goldstein's protocols, and—because of loss of teeth—facial heights were omitted in some individuals in the Paracho series. The range in number of observations for any age group is indicated in tables 1 and 2, but for most dimensions the larger number of individuals were measured. In all series the 21–30 year old group is the most numerous and, unless otherwise specified, age trends refer to the comparison of this group with older groups—especially with the 51–up age group. Because of the small number of individuals over 51 years old in Lasker's male series, any judgment based on failure of a measurement to show significant changes in this age group should be considered tentative.

FINDINGS

General size. The individuals studied in Paracho were not weighed. For Goldstein's series weight continues to increase with age except for the oldest males.

For both Goldstein's series and our own, the older individuals are slightly shorter. This difference is statistically significant except for the Paracho females series. When the 80 and 90 year-old males are excluded, however, the coefficient, of correlation between age and stature is not statistically significant. For Paracho males 18–73 years old, $r = -0.12$.

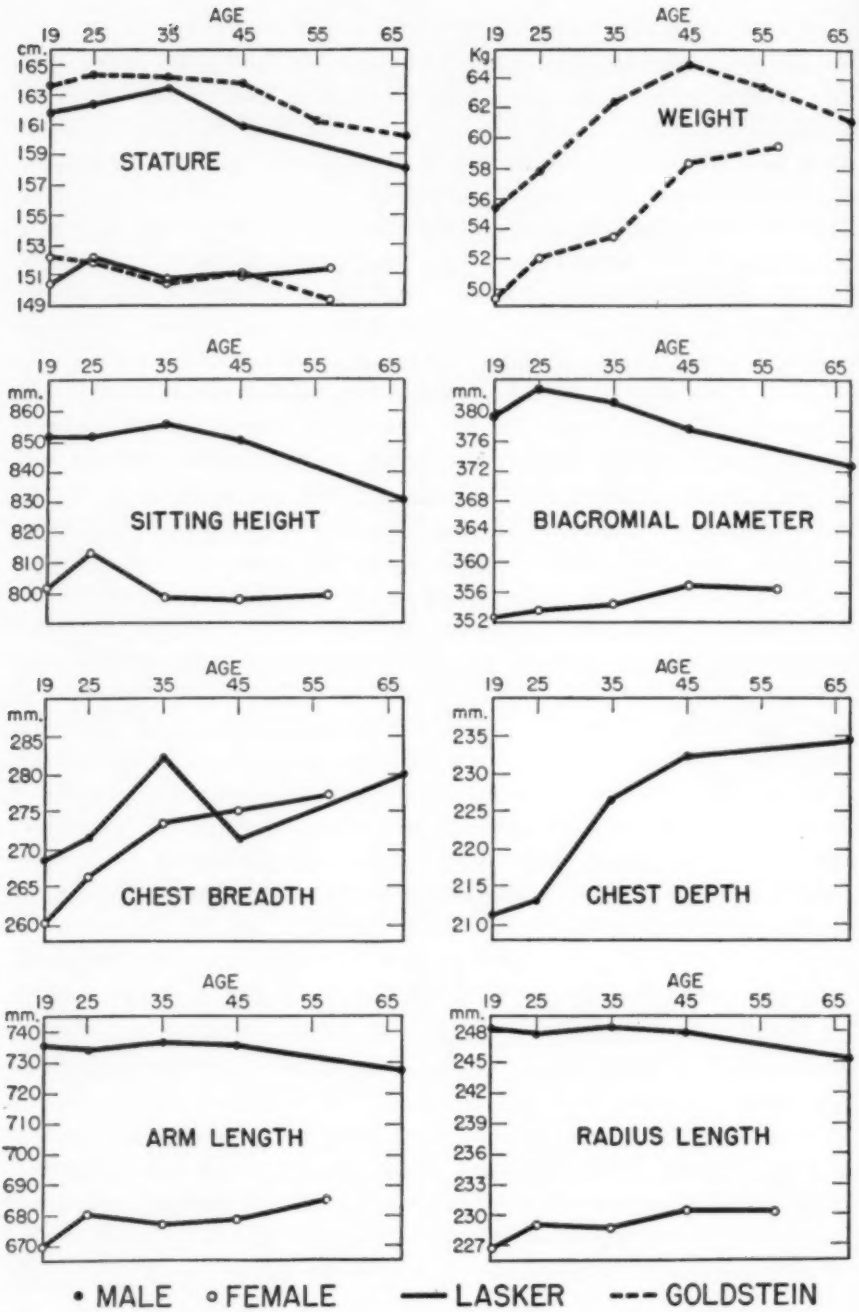

FIG. 1. GRAPHS SHOWING MEAN MEASUREMENTS OF MEXICANS OF DIFFERENT AGE GROUPS.

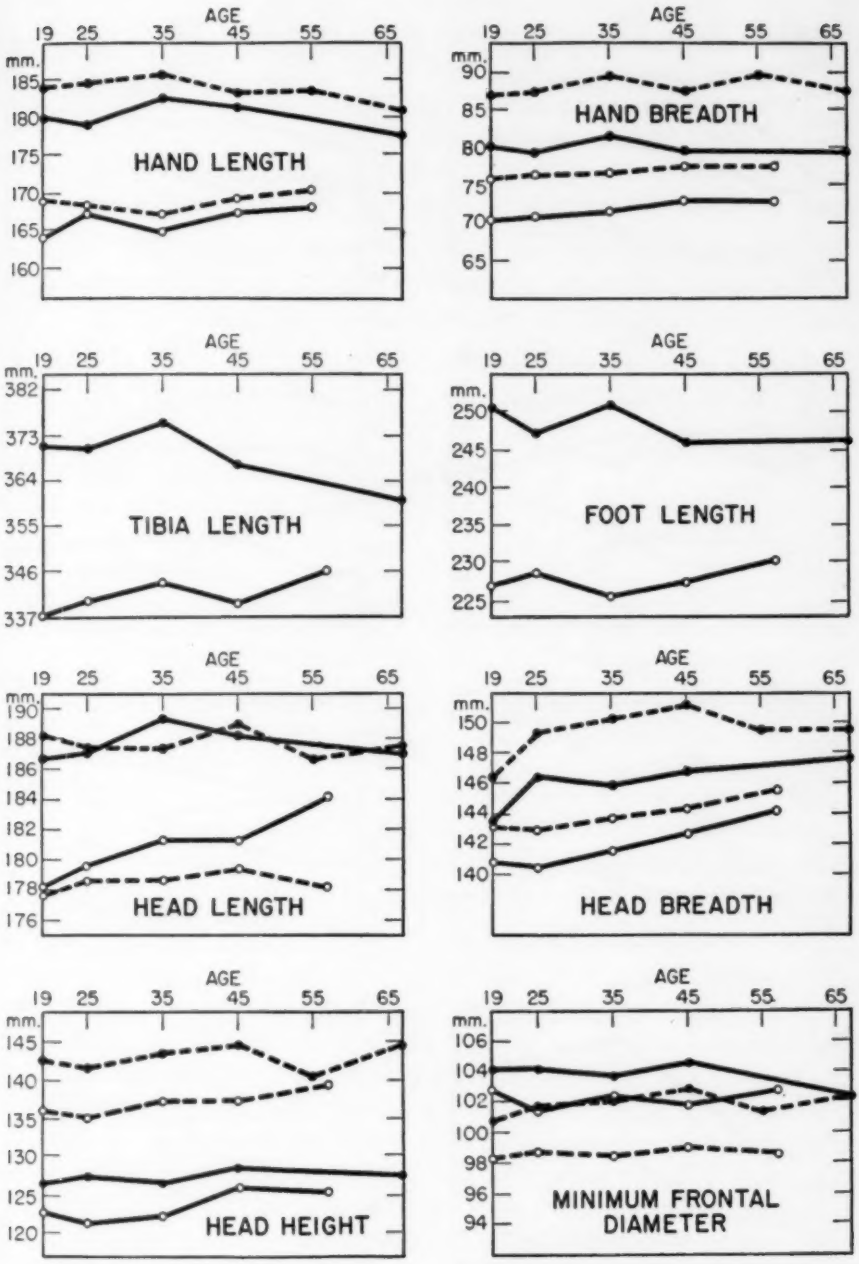

FIG. 2. GRAPHS SHOWING MEAN MEASUREMENTS OF MEXICANS OF DIFFERENT AGE GROUPS.

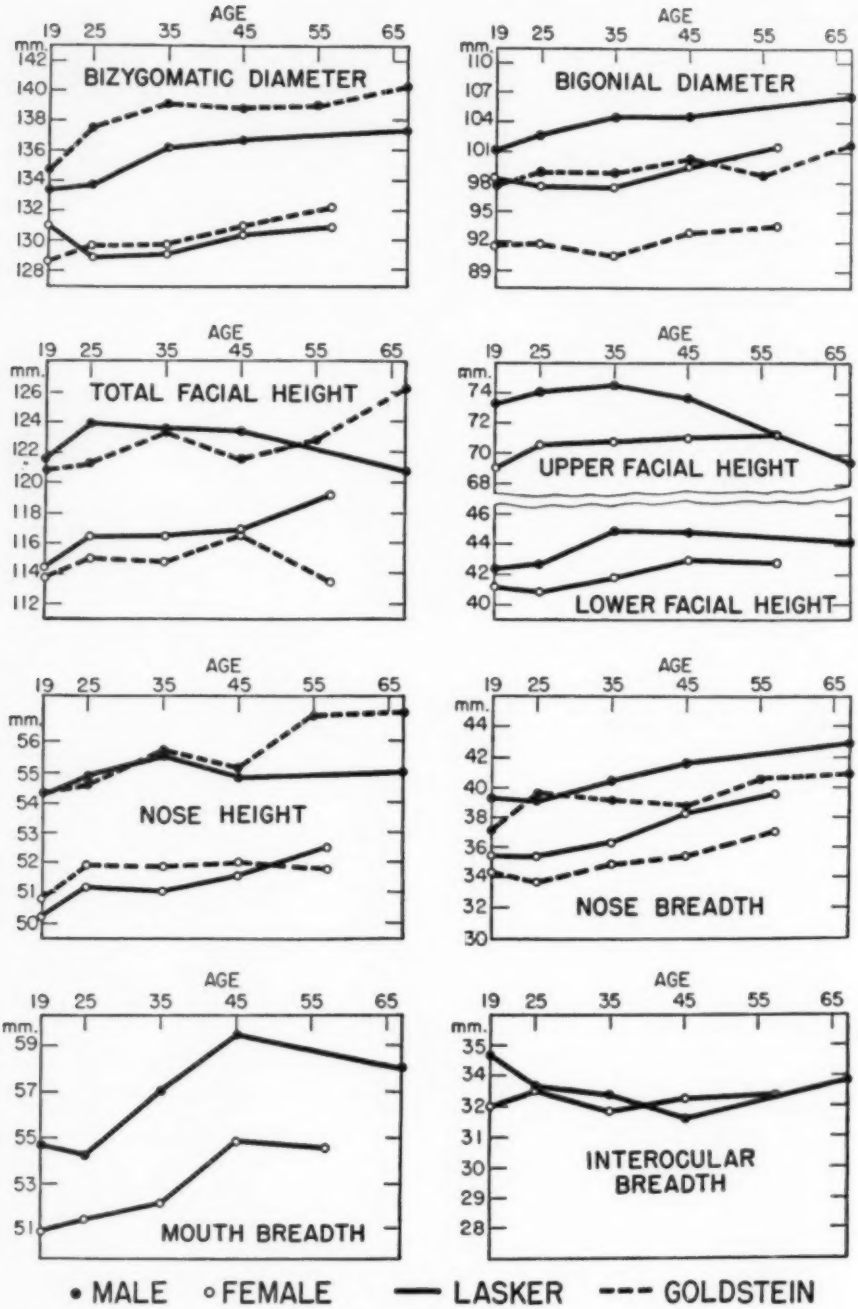
AGE
19 25 35 45 55 65
mm.
BIZYGOMATIC DIAMETER
142 140 138 136 134 132 130 128
BIGONIAL DIAMETER
110 107 104 101 98 95 92 89
TOTAL FACIAL HEIGHT
126 124 122 120 118 116 114 112
UPPER FACIAL HEIGHT
74 72 70 68
LOWER FACIAL HEIGHT
46 44 42 40
NOSE HEIGHT
56 55 54 53 52 51 50
NOSE BREADTH
44 42 40 38 36 34 32 30
MOUTH BREADTH
59 57 55 53 51
INTEROCULAR BREADTH
35 34 32 31 30 29 28
• MALE ○ FEMALE — LASKER --- GOLDSTEIN

FIG. 3. GRAPHS SHOWING MEAN MEASUREMENTS OF MEXICANS OF DIFFERENT AGE GROUPS.

Trunk dimensions. Data are available only for the Paracho series. Like stature, sitting height shows, and biacromial diameter tends to show, a decrease with age in the males. There is a less marked decrease in sitting height in females than in males. Chest width increases and biacromial diameter tends to increase with age in females. In males, chest depth increases with age and chest breadth tends to do so.

Dimensions of the extremities. On the extremities only the hand dimensions were measured by Goldstein. For these the age curves closely parallel those from Paracho data. For the Paracho series, the lengths of

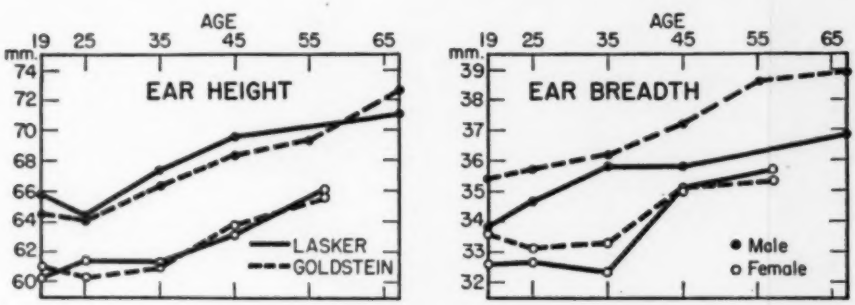

FIG. 4. GRAPHS SHOWING MEAN EAR LENGTH AND BREADTH OF MEXICANS OF DIFFERENT AGE GROUPS.

the total arm, radius, tibia, and foot were also measured. All of the measurements of the limbs show a tendency to be smaller in males after the 31–40 year-old period. For the females, however, there is, if anything, a tendency to larger dimensions with increased age, especially after 31–40 years of age.

Head dimensions. In head length there is little tendency to differ with age except for an increase with age in the Paracho females. In head breadth and head height there is a significant increase with age in both female series and a tendency to increase is also seen in the males. Despite the fact that Goldstein's data yield higher values than ours for head breadth and, especially, head height (he uses porion-bregna height, we use tragion-vertex height), his age curves for these dimensions are essentially parallel to those drawn from Paracho data. Minimum frontal diameter and interocular width show no appreciable trends.

Face dimensions. The facial widths (bizygomatic diameter and bi-

TABLE 1

Mean Dimension (in mm.) by Age

PARACHO SEDENTES (LASKER)

	MALES						FEMALES					
	I	II	III	IV	V	Significant differences	I	II	III	IV	V	Significant differences
Age group (in years)	18–20	21–30	31–40	41–50	51–up	V less II	18–20	21–30	31–40	41–50	51–up	V less II
Number	19	32–33	27–28	14–15	7–16		14	38–39	34–37	28–32	26–35	
Mean age (in years)	19.4	25.0	36.9	48.0	68.0		19.4	25.6	36.1	46.4	59.8	
Stature	1618.9	1624.0	1634.6	1609.2	1581.0	–	1504.2	1520.5	1507.3	1509.3	1514.8	o
Sitting height	852.0	852.0	855.7	851.3	831.5	–	802.1	812.8	798.2	797.8	799.6	–
Biacromial diameter	379.3	382.9	381.2	377.9	372.8	o	352.4	353.5	354.3	356.8	356.2	o
Chest breadth	268.9	271.7	282.5	271.1	280.0	o	260.3	266.6	273.5	275.1	277.2	+
Chest depth	211.6	213.3	226.8	232.2	234.6	+						
Arm length	735.4	734.8	736.8	735.1	727.8	o	669.3	680.1	676.8	678.4	685.2	o
Radius length	248.2	247.7	248.3	247.8	245.2	o	226.6	228.8	228.4	230.4	230.2	o
Hand length	180.0	179.1	182.6	181.4	177.9	o	164.3	167.4	164.9	167.4	168.1	o
Hand breadth	80.1	79.6	81.4	79.3	79.1	o	70.6	70.8	71.6	72.9	72.3	o
Tibia length	370.8	370.3	375.5	367.3	360.3	o	337.6	340.3	344.1	339.6	346.2	o
Foot length	250.5	247.1	250.9	245.9	245.9	o	227.0	228.7	225.6	227.1	230.2	o
Head length	186.7	187.1	189.3	188.3	187.1	o	178.2	179.6	181.3	181.2	184.1	+
Head breadth	143.4	146.2	145.9	146.7	147.6	o	140.9	140.4	141.6	142.7	144.1	+
Head height	126.5	127.4	126.5	128.4	127.8	o	122.9	121.1	122.5	126.0	125.4	+
Minimum frontal diameter	104.0	104.1	103.8	104.6	102.2	o	102.9	101.6	102.2	101.8	102.9	o
Interocular width	33.6	32.7	32.4	31.6	32.9	o	32.0	32.5	31.9	32.2	32.3	o
Bizygomatic diameter	133.4	133.8	136.2	136.8	137.2	+	131.0	129.0	129.1	130.6	131.0	o
Bigonial diameter	101.2	102.7	104.2	104.3	107.1	+	98.6	97.7	97.5	99.7	101.7	+
Total facial height	121.6	124.0	123.6	123.5	120.9	o	114.5	116.4	116.5	116.9	119.2	+
Upper facial height	73.3	74.1	74.7	73.6	69.3	o	69.0	70.5	70.7	71.0	71.4	o
Lower facial height	42.3	42.6	45.0	44.7	44.2	o	41.0	40.8	41.6	42.9	42.5	+
Nose height	54.3	54.9	55.5	54.8	55.0	o	50.1	51.2	51.0	51.6	52.5	o
Nose breadth	39.4	39.0	40.3	41.6	42.9	+	35.6	35.5	36.2	38.2	39.6	+
Mouth width	54.7	54.2	57.0	59.2	57.5	+	50.9	51.5	52.2	54.8	54.5	+
Ear breadth	33.8	34.6	35.9	35.8	36.8	+	32.6	32.7	32.4	35.0	35.7	+
Ear height	65.8	64.2	67.4	69.5	71.0	+	60.1	61.4	61.2	63.1	66.0	+

+ Oldest group larger by two or more times the standard error of the difference.

– Oldest group smaller by two or more times the standard error of the difference.

o Difference not statistically significant.

TABLE 2

+ Oldest group larger by two or more times the standard error of the difference.
– Oldest group smaller by two or more times the standard error of the difference.
o Difference not statistically significant.

TABLE 2

Mean Dimension (in mm.) by Age

MEXICANS (GOLDSTEIN)

	MALES						FEMALES					
	I	II	III	IV	V	Significant differences	I	II	III	IV	V	Significant differences
Age group (in years)	18–20	21–30	31–40	41–50	51–up	V less II	18–20	21–30	31–40	41–50	51–up	V less II
Number	28–37	71–107	21–28	26–40	63–86		37–49	70–92	22–41	58–72	27–46	
Mean age (in years)	19.1	24.9	33.7	45.9	58.3		19.0	24.4	35.1	45.5	57.3	
Weight (in kg.)	55.5	58.0	62.5	65.1	61.2	o	49.4	52.1	53.5	58.6	59.5	+
Stature	1636.7	1644.0	1642.2	1638.5	1603.2	–	1524.3	1519.8	1505.6	1510.9	1492.8	–
Hand length	184.0	184.9	185.9	183.3	181.2	o	169.3	168.2	167.3	169.5	170.5	o
Hand breadth	87.2	87.2	89.5	87.5	87.2	o	76.2	76.6	76.8	78.7	78.6	+
Head length	188.2	187.4	187.4	189.0	187.5	o	177.7	178.6	178.7	179.4	178.1	o
Head breadth	147.2	149.2	150.2	151.0	149.5	o	143.1	143.0	143.8	144.1	145.5	+
Head height	142.4	141.5	143.7	144.7	144.4	+	136.0	135.0	137.4	137.4	139.7	+
Minimum frontal diameter	100.9	101.7	102.1	103.0	102.3	o	98.4	98.8	98.4	99.0	98.5	o
Bizygomatic diameter	134.9	137.6	139.1	139.0	140.3	+	128.9	129.9	129.8	131.0	132.3	+
Bigonial diameter	97.8	99.0	98.7	100.4	102.0	+	91.7	91.9	90.8	93.1	93.6	o
Total facial height	120.9	121.4	123.4	121.6	126.3	+	113.8	115.0	114.9	116.6	113.4	o
Nose height	54.3	54.6	55.6	55.2	56.9	+	50.8	52.0	51.8	52.0	51.8	o
Nose breadth	37.2	39.5	39.0	38.8	40.9	+	34.2	33.9	34.9	35.3	37.0	+
Ear breadth	35.4	35.7	36.2	37.2	38.8	+	33.6	33.1	33.3	35.1	35.4	+
Ear height	64.5	64.1	66.3	68.3	72.7	+	61.0	60.3	61.1	63.8	65.7	+

+ Oldest group larger by two or more times the standard error of the difference.
– Oldest group smaller by two or more times the standard error of the difference.
o Difference not statistically significant.

gonial diameter) manifest an increase with age or a steady tendency in that direction in both sexes and for both sets of observations. Total morphological face height is greater in older females in Paracho and in older males in Goldstein's series. A parallel increase is to be observed for lower facial height in Paracho females, and the same tendency is seen in upper facial height. Paracho males of the oldest groups, however, show a tendency to decrease in all three face height dimensions; a majority of the individuals in the oldest age group had lost teeth with consequent reabsorption of alveolar bone and facial shortening. Nose height shows an increase with age in Goldstein's male series and a similar tendency in Paracho females.

As for those measurements primarily dependent on soft parts, nose breadth increases steadily with age in all series; mouth width also increases with age, although not in the oldest group; ear dimensions, especially height, also manifest steady increases with age. These changes are not only statistically significant but are of considerable magnitude.

Sex differences. In a number of measurements (stature, sitting height, biacromial diameter, chest width, total arm length, radius length, hand length and breadth, tibia length, foot length, total and upper facial height and nose height) the trend is for older females from Paracho to be larger, and older males to be smaller. At least the curves for the two sexes converge at the older ages. In general the dimensions involved are the ones most highly correlated with stature and which therefor best show general size factors (Lasker '46). No ready explanation suggests itself. Goldstein's data contain no trunk measurements; his only extremity measurements, the hand dimensions, do, however, suggest convergence of males and females in the older age groups.

DISCUSSION

Adult males from Paracho, and to a lesser extent the other Mexican series, show a close similarity in age changes in measurements to a series of nearly 10,000 Irish males described by Hooton and Dupertius ('51). In both series stature and sitting height reach a maximum in the thirties and decline thereafter. Arm length in Paracho males and span in the Irish also reach their maximum in this decade. Chest dimensions increase throughout life in men in Ireland as does chest depth in men in Paracho. In the head dimensions the parellelism is not quite so close. Facial breadths, notably the bizygomatic and bigonial diameters, and

the nose breadth increase at least into the fifties in both studies, but in facial height and nose height the Irish show continued increases longer than the Paracho males series and resemble Goldstein's Mexican series more closely.

Hooton and Dupertius were apparently surprised at their finding of a continuous increase in facial dimensions during the ages when most other measurements were decreasing, for they say of the upper facial height that, " rather astonishingly, this measurement (nasion-prosthion) continues its increase through the 50–54 year age group," and of bigonial diameter that, " it is very difficult to avoid the conclusion that bigonial increases up to old age . . ." Yet this is not a phenomenon peculiar to the Mexican and Irish studies. Pfitzner (1899) presented evidence that increase in dimensions of the face probably continues at least to the 51–60 year old group in Alsatians. Goldstein ('36) compared Jewish males over 60 years of age with young adults and, in this group also, the facial breadths are larger in the old individuals but facial lengths other than nose height are smaller because of loss of teeth and attendant alveolar absorption. In a survery of 1,067 adult male Albanians, Coon ('50) reported increases in total facial height throughout life, and in bizygomatic diameter until the late forties. Using the same series of American soldiers as Randall, Baer (personal communication), in a study extending only up to age 33, finds significant increases in facial length and breadth throughout the period under consideration.

The curves for age changes reported for Mexico are essentially similar to the findings in other groups. The chief factors responsible for the age changes apparently cut across geographic and racial boundaries.

Any of three types of factors may account for the age differences (Morant '49). 1. There may be an actual change with age. 2. There may be a shift in the population norms so that the later born (and hence younger) individuals differ from those born some years sooner. 3. A selective death rate might eliminate a disproportionate number of individuals of some particular type.

That the first factor is an important one in the present series is suggested by a number of parallels to the results of Büchi ('50). In his analysis the second and third factor were excluded, for he re-examined the same series of 196 Swiss adults after an interval of nine years. Actual changes recorded included a decrease in stature, but in sitting height the decrease was limited to the oldest ages. Length of the

inferior extremity and span decreased with age in Büchi's study. However, the former was derived by subtracting sitting height from stature, and span is also a composite measurement into which functional factors enter. Therefore, these decreases are not evidence for a shortening of bones as would be decreases in such measurements as tibia or radius length. It is unfortunate that measurements were not published for at least one of the long bones. In another place, however, Büchi ('49) does give data for hand length and breadth; these continue to increase in size except in the oldest age group.

In Paracho, males in the oldest group have significantly shorter tibiae than those in the 31–40 year old group. In such an absolute diminution with age in length of long bones, it is possible that some selective factor is at work. One such factor might be an overall increase in size of the later-born generation. Bowles ('32), among others, has controlled the age factor and traced a secular trend to increased body size in various parts of the world. Although the same influences might be expected to hold for both sexes in Mexico, it should be noted that the tendency of extremity measurements to decrease in size with age was recorded for males only.

An alternative factor, and one which might affect the male series but not the female series, is the selection of emigrants. Few females have left Paracho, but a majority of the adult males of the community have been in the United States for longer or shorter periods of time. As emigrants are in general somewhat larger than sedentes (who alone are considered in this study) and as some of the younger sedentes are really pre-emigrants, the downward trend in size with age might be the effect of selective migration. This would account also for differences between male and female curves. However, migrants who first left after the age of 27 are not appreciably different from sedentes. In fact, as we have shown in another place (Lasker '52), the more tenable conclusion is that the chief cause of the larger size of those who emigrated when still young is some factor in the environment during this period rather than a difference at the time of migration. There was little to suggest the influence of selective migration.

As for selective death rates, there is no evidence to support the hypothesis. For Büchi's findings, where the changes are shown to occur in individuals, such a factor would be excluded. Morant ('49) also finds the hypothesis unacceptable, although Hooton and Dupertuis ('51) give it some credence.

One way in which measurements may vary with age is through changes in the soft tissues. This is obviously probable for such measurements of cartilagionus parts as the dimensions of the ears and nose (especially breadth). Stature, too, may be influenced through changes in the intervertebral fibrocartilages. Trotter and Gleser ('51) have shown that as between younger and older individuals with identical length of long bones, the older individuals are shorter in stature.

Fat may also influence many measurements. It seems probable that all circumferences, the chest dimensions, and other trunk diameters are influenced by state of fatness. This is indicated in Randall's ('49) study based on a large number of individuals between the ages of 17 and 26, although the measurements published include few of those standard to anthropology. Keys and his associates ('50) have measured the decrease in numerous dimensions during partial starvation. It is possible that changes in the head and face also, to some extent, may be affected by the amount of overlying soft tissues; Ivanovsky ('23) has reported that head and face dimensions decrease during starvation.

Increase in head dimensions has been reported by Büchi for circumference, length, breadth and minimum frontal diameter. His data agree well with our observation that the older individuals have the larger head dimensions, especially breadth and height, except for the very oldest group where the trend is reversed. In bizygomatic diameter, morphologic face height and bigonial diameter also, Büchi demonstrates a continued growth which is reversed only in the oldest age group; and in upper facial height the continued growth is even more striking. In general, Mexicans show this same tendency toward larger faces in the older groups. There is a strong suggestion that increased size of the face may to some extent be caused by appositional growth of bone although there may possibly be some changes in overlying soft tissues also. As Hooton and Dupertuis ('51) say in speaking of bigonial diameter: "We have either to press the selective explanation very far indeed, or admit that growth changes (in the way of increment) continue for a much longer time than most anthropologists have supposed to be the case."

SUMMARY

1. Differences in measurements by age group for 268 adult Mexican sedentes from Paracho, Michoacán, are compared with similar data for 608 adult Mexicans measured by Goldstein.

2. On the average, stature and sitting height are smaller in individuals in the older age groups than in the 21–30 year-old group. Measurements of the limbs show a tendency in the same direction, at least for males.

3. Measurements of the chest and of the head show less consistent tendencies, but some of these dimensions are significantly larger in the older age groups. Facial measurements, especially breadths, are more consistently larger in older groups. The soft parts of the nose, mouth and ears are significantly larger in the older than in the younger adults.

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Human Biology

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THE JOHNS HOPKINS PRESS, *Publishers*

BALTIMORE—18, MARYLAND, U. S. A.